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TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 65, 80
The Levees of the Mississippi River (illustrated, with inset).....66, 77
Parlor Cars for the Brooklyn Heights R. R. (illustrated)..... 75
Curved Masonry Dam for Water-Works of the city of Remscheid, Germany (with inset)..... 76
Will There be a Carbide Industry?..... 78
Some Facts about Acetylene Gas..... 78
EDITORIAL NOTES..... 80
The Water Supply Problem in Jersey City—The Railway Signaling Club in Chicago—Qualifications for Membership in Railway Clubs Parlor Cars for Electric Railways—The Proposed National Highway Commission—A Model Contribution to Chemical Literature.
EDITORIAL
Calcium Carbide and Acetylene..... 73
LETTERS TO THE EDITOR.....74, 75
Simpler Formulas for the Flow of Water in Pipes—The Collision in the St. Louis Tunnel Caused by a Sleepy Signalman—Effect of Grades on Hauling Capacity of Locomotives—Notes and Queries.

The Jersey City water supply contract has been declared invalid by the State Supreme Court. The principal ground for the decision, aside from the indefiniteness of the specifications, was, in the language of the syllabus:

Bids having been expressly invited upon the condition that the contractor should provide reservoirs capable of storing a water supply for 100 days' delivery at the rate of 50,000,000 gallons per diem, the contract was not lawfully awarded to one of the bidders for the reason that it offered to provide a storage capacity sufficient for 250 days.

The contract was awarded in the fall of 1895 for a new gravity water supply from the Rockaway River. It was given to the Jersey City Water Co. at a price, in case the city should buy the works, $2,300,000 above the offer of the lowest bidder. The award was taken into the court by a number of taxpayers and interested competitive bidders. At the same time a contract for a temporary supply was awarded to the East Jersey Water Co., to be taken from the surplus waters of the Newark pipe line. This supply is now in use, but as noted in our issue of Jan. 16, only a small amount of water can be furnished Jersey City, owing to the deficient carrying capacity of the Newark pipe line. The decision cited above also affirms that the water rights in the Rockaway drainage area pertaining to the Morris Canal might be condemned for water supply purposes, if proper legislative authority were secured, but that no authority now exists which would enable those waters to be condemned for Jersey City. This part of the opinion serves to temporarily strengthen the hold of the water syndicate, or the East Jersey Water Co., on the Rockaway drainage area, but to make clear that this hold need be only temporary whenever the people of New Jersey choose to assert their independence of the syndicate.

The right of the city of Philadelphia to use the water of the Schuylkill River, in connection with the proposed Berwyn water supply, is the subject of an opinion lately addressed by City Solicitor Kinsey to the Director of Public Works. Mr. Kinsey, after tracing the history of the city's water supply from 1701, and from 1799, when the first pumping engine was introduced, concludes as follows: That Philadelphia has the natural right to use the Schuylkill water to its fullest extent for purely domestic purposes, irrespective of the rights of the Schuylkill Navigation Co., and is only limited by the rights of towns further up the river to use this water for a similar purpose. But persons and towns up stream may use as much water as necessary for domestic purposes without reference to the needs of Philadelphia By the agreement with the Schuylkill Navigation Co. the city acquired the right to use for any purpose all the water in the pools in excess of that required for navigation; and by long use and legislative sanction and direction, Philadelphia acquired the right to use and receive the waters of the Schuylkill and its tributaries, in excess of that required by individuals and towns on these streams above Philadelphia. The town of Berwyn, Pa., not situated on the Schuylkill water-shed, now proposes to divert the water of Pickering Creek to its own use and away from communities living on said creek. Mr. Kinsey concludes by saying that if it can be shown that such diversion is or will be prejudicial to the rights of Philadelphia, there seems to be no reasonable doubt but that the Berwyn authorities can be restrained from committing the injury. He advises investigation as to the extent of the proposed diversion.

Rochester, N. Y., is spending $1,500,000 in building an east side trunk sewer and a west side sewer; but, while these sewers will abate nuisances caused by the discharge of sewage into small streams, the question of final sewage disposal is still unsolved, as the outlet is into the Genesee River 5 miles above its mouth. This 5 miles of river has an average depth of 24 ft., and is from 280 to 480 ft. wide; but the summer current is almost nothing, at times not exceeding one mile in three days. City Engineer J. Y. McClintock calls attention to work necessary in the immediate future in this connection, and strongly and wisely urges that the subject be studied and reported upon by the ablest experts in engineering and in law that can be secured. The lawyers are needed because one of the schemes of relief proposed involves the storage of Genesee River water by a 130 ft. dam and the creation of a hydraulic plant of 30,000 HP. While this project would provide the flow in the lower river needed and be advantageous to the city, it necessitates disputing the claim of the State to the water of the Genesee for canal purposes. This dispute bristles with complicated legal details, and both sides of the case urgently demand the best expert service.

The awards for the best plans for the Montreal bridge across the St. Lawrence have not yet been declared, notwithstanding the reports to that effect which have appeared in the daily papers. From the large number of plans submitted three have been selected, and have been submitted to the Government engineers. When they have reported the decision will be made as to the first and second best plans. The bridge is to be built for the Montreal Bridge Co., of which Mr. C. N. Armstrong is Managing Director. The location and general designs were published in our issue of Feb. 14, 1895.

Another East River bridge project is reported as being pushed by Mr. Frederick Uhlmann on a charter held since 1892, which included also the bridge site lately sold by Mr. Uhlmann and his friends to the new East River Bridge commission. These two bridges were to have a common terminal at Grand St., New York, and as the commission now owns this terminal, Mr. Uhlmann will have to find another for the other leg of the V. The charter for the bridge now being pushed by Mr. Uhlmann calls for a beginning at Hudson Ave., in Brooklyn, and legislature will be needed to obtain a new landing in New York and the permission to build an elevated road across New York. The real object of Mr. Uhlmann and those interested with him appears to be to extend the Brooklyn elevated railways into New York city.

The Michigan Central Bridge Co. filed articles of association with the Secretary of State of Michigan on Jan. 23 for the purpose of constructing a railway bridge over the Detroit River at Detroit. The capital is $2,000,000, one-half the estimated cost of the bridge, which is to be about three miles long. The incorporators are Cornelius Vanderbilt, Chauncey M. Depew and C. F. Cox, of New York, and H. B. Ledyard, Ashley Pond and H. M. Campbell, of Detroit.

The most serious railway accident of the week was a grade-crossing collision Jan. 25 near Santa Clara, Cal., where the Southern Pacific Ry. crosses a narrow-gage line. The Monterey express, which had the right of way, was passing over the crossing, when the signalman became confused and signalled a train on the narrow-gage line to come ahead. The engine of this train and the baggage car and a day car of the express were badly wrecked. Seven persons were injured, some seriously. ——The caving in of the ground over a coal mine at Sugar Loaf, Pa., caused the derailment of a passenger train on the Lehigh Valley R. R. Jan. 20. The engine was overturned and the engineman was killed. The depression was about 8 ft. deep and 20 ft. long.

The rear driving axle of the engine of a passenger train on the Central R. R. of New Jersey broke Jan. 22, just as the train was starting from Elizabeth, N. J. As the speed was slow, only the engine was derailed, and nobody was hurt.

The steam chest of a locomotive on the New York & Long Branch R. R. burst at the station at Point Pleasant, N. J., on Jan. 25. No one was injured.

A landslide blocked the New York Central R. R. two miles above Tarrytown, N. Y., Jan. 24, but one track was kept clear for traffic.

The boiler of a Pennsylvania R. R. locomotive exploded Jan. 22 while the engine was hauling a fast passenger train, near South Charleston, O. The train consisted of nine passenger cars and two mail cars, none of which were derailed. The engineman and fireman were killed and some of the passengers slightly injured.

The trestle at Glencoe, Pa., on the Baltimore & Ohio R. R., gave way under a derailed train, Jan. 22, and six cars went down with the wreck, while others were smashed on the remaining portion of the structure. A broken brake-beam is said to have caused the derailment.

By the breaking of an ice gorge in the Maumee River about eight miles above Toledo, O., two spans of new bridge in the course of construction were carried away. The loss will be about $50,000.

A flywheel at the Duquesne Tube Works, Pittsburg, Pa., burst Jan. 24, and one of the pieces killed a man in the engine room.

The cable of an elevator at the Ohio Steel Works, Youngstown, O., parted Jan. 22. Of three men in the cage, one was killed and two were seriously injured.

The explosion of dynamite cartridges which were being thawed out at a fire by laborers near Bixler's, Pa., killed one man, fatally injured another, and more or less seriously injured eight other men.

An explosion of a wagon load of nitro glycerine took place at St. Mary's, O., on Jan. 25, killing the driver and two horses. The shock was felt for many miles around.

A 12-in. main carrying natural gas under 300 lbs pressure from the gas pumping station at Red Key, Ind., in the center of the Ohio and Indiana gas field, burst at the pumping station, on Jan. 21, killing one man, injuring seriously four others, and destroying the station, causing a loss of about $100,000. The cause is said to have been excessive pressure on the pipe. The escaping gas was lighted by the fires under the boilers in the station, and exploded, wrecking and setting fire to the station. The station supplied Lima, O., and intermediate towns with gas. It will be rebuilt at once.

The American Line Steamship "St. Paul," on the night of Jan. 25, and during a dense fog, being off its course, ran aground on the sand beach opposite Long Branch, N. J. The "St. Paul" was approaching New York harbor, and the accident is ascribed to a false reading of the hand-lead by one of the officers of the ship, the 7-fathom mark being mistaken for 17 fathoms. Up to this date, Jan. 30, all efforts to haul off the big steamship have failed, and she lies imbedded in about 10 ft. of sand for the whole length of her keel. Passengers and cargo have been landed, and the officers of the ship and the Merritt Wrecking Co, await, with all preparations made, favorable wind and tide. The "St. Paul" was launched from the Cramp shipyard on April 10, 1895. She is 554 ft. long, over all, 64 ft. wide, 42 ft molded depth, and at 26 ft. draft has a displacement of 16,000 tons.

A steam boiler, 40 years old, running a cotton-gin near Cummock, N. C., exploded on Jan. 21, killing two men. A rusty valve, which prevented the water from getting into the boiler, is reported to have been the cause.

Explosions occurred in two coal pits at Pont-y-Pridd, Wales, on Jan. 27, entombing a large number of miners and destroying the shafts by fire. The latest dispatches say that 43 men were killed, and that 42 had been rescued alive.

Electric currents have been playing new pranks in Brooklyn. A wire of the Municipal Electric Light Co., from which the insulation had worn off by swaying against the branches of trees, came in contact with their water-soaked limbs on the night of Jan. 24, and gave a startling pyrotechnic display, finally setting fire to the trees. One tree was completely burned except the charred trunk. Before it took fire it was enveloped in blue flame.

Another curious freak of the electric current caused great annoyance to passengers on the Metropolitan Elevated Railroad in Chicago on the night of Jan. 22. The current is delivered to the cars through a third rail. A sleety rain caused a coating of wet ice to form over the rail and the ties, by which the current was grounded and the whole car system came to a standstill until the ice could be cleared from the line, which took several hours. As drops of rain fell upon the electrified ice sparks were given out, and at times the whole line glowed as if it were ablaze. The trouble lasted from 8 to 11 p. m. It makes an argument against the three-rail and in favor of the overhead trolley system.

A charge of dynamite in a bore-hole in an excavation in 138th St., New York, exploded prematurely on Jan. 23, killing one man and injuring a second. A series of four holes was fired, and one of them failed to explode. A workman attempted to draw the cartridge with a steel instrument called a spoon, which probably broke through the covering of the cartridge, causing the explosion. The man using the spoon was severely injured, and another who was near by was killed by the flying rock fragments.

Boston, Mass., through the annual report of its Harbor and Land Commissioners, asks that the Federal Government deepens the main channel in its harbor to 30 feet at mean low water. At the present time the government is at work on a project to provide 27 ft. of water, at mean low tide, and a channel 1,000 ft. wide up to the city wharves. The Commissioners claim that the increase in the draft of vessels since the work was entered upon, makes this depth insufficient for the needs of the harbor, and they say that the expenditure of less than $750,000 will remove all obstructions and provide for the deeper channel.

THE LEVEES OF THE MISSISSIPPI RIVER.

By William Starling,* M. Am. Soc. C. E.

(With Inset).

The conformation of the flood plain of the Mississippi renders it peculiarly favorable to protection by levees. By the alternate approach and recession of the hills which border it, the great plain, or "bottom," is divided into coves or basins, which are usually separated, at either end, from the adjoining basins by ridges, which are above overflow, and which, therefore, afford points of support for independent levee systems.

It is not found profitable to protect very narrow tracts, for the simple reason that it costs as much to protect an area one mile deep as fifty. Now the average width of the alluvial valley of the Mississippi is about 35 miles. Were the levees continuous on both sides, one mile of levee on each bank would protect 17.5 miles of territory. There are, however, considerable stretches on the left bank (from Cairo to Memphis, and from Vicksburg to Baton Rouge) where the river runs so close to the hills that no levees are required. Approximately speaking, when the levees now building or projected are completed, each linear mile of embankment will protect about 20 square miles of bottom land.

Drainage of the Levee Basins.

The great basins, of course, must have drainage. In regions less fortunately situated this must often be artificial. In Holland, for instance, a great part of the rain and seep water must be got rid of by pumping. In the case of the Mississippi the great and continuous slope of the flood plain obviates this difficulty at some sacrifice. Each basin is drained by one or more rivers, which usually run close to the base of the hills, and whose tributaries ramify to the uttermost recesses of the district. In accordance with the usual law of sedimentary streams the tract of land which adjoins the Mississippi is higher than any other part of the plain, and there is a gradual slope back, in each instance, to the tributary. There is thus a very complete system of drainage to each district, the outfall being the foot of the basin, usually defined by the chain of hills which forms its boundary on the side remote from the Mississippi.

It is impracticable to levee the mouths of the tributaries, because then the drainage, at high water, would have to be by pumping, and the amount of water which would accumulate would be very great. In time of flood the rainfall is often excessive. In April, 1874, in the Yazoo Basin, it reached 22 ins., and the rain-water discharge of the Yazoo River is sometimes 100,000 cu. ft. per second or more. This is 60 or 70 times the capacity of the greatest pumping plants in existence.

If the front of a basin be sealed by levees, joined to the hills at its head and extending as far as the mouth of its drainage stream at its foot, the water of the Mississippi can get access to it only through the gap caused by the entrance of the tributary. The plain of the Yazoo Basin has a mean slope of about 8 ins. to the mile. At a distance of 15 miles above the lower end of the levee system, therefore, the level of the back-water from the Mississippi will be about 10 ft. below that of the river-water. Now, the hills which bound the basins usually approach the river gradually, so that the lower end of the basin has much less than the average width. In the instance cited the levees extended to the mouth of the Yazoo River. The area of the alluvial tract from its mouth to a line 15 miles above it would be about 250 square miles. In the case of the St. Francis it would hardly be more than half of this amount. Of these areas large tracts have so high a situation that they are several feet above the back-water. Part of the remainder is irreclaimable swamp. On the whole, the sacrifice is small compared with the benefit.

Materials Used in Levee Building.

The levees are plain, earth embankments, without puddle walls or foundations of any kind, unless, indeed, under the latter head we include muck-ditches, hereafter to be mentioned.

From economical considerations, the choice of materials is confined to the limits of an ordinary haul. Now, there are several kinds of earth to be found in the Mississippi Valley. There is: first, sand; second, clay; and third, loam. None of these is usually pure, but they are mixed in various proportions, as they dropped from the water which once carried them in suspension. The sand is usually fine and mixed with earthy particles, so that it is not good for cement. The clay is of the blue plastic variety, and varies according to its origin. In the older part of the flood-plain it corresponds to the "gumbo" of some of the Western States. Geologically, it is thought to be the equivalent of the "boulder-till" of the drift period, assorted and separated from the coarser constituents which accompany it in more northern situations.

There are many parts of the flood-plain, however, which are of very recent origin; some have been formed within the memory of man, and some are even now in process of construction. The materials for the building of new tracts have generally been derived from the older portions of the plain. They are the workings-over of the original deposits. They are therefore essentially of the same character, and are not always to be distinguished from the older soils.

The Mississippi Valley from Cairo to the Gulf.
(From Trans. Am. Soc. C. E., Vol. 34.)

The ancient and the recent clays are confounded together in common parlance, and are embraced collectively under the name of "buckshot" soil, from its peculiarity of breaking, when dry, into minute fragments about the size of bullets. It is, as usually found, not at all pure, but is mixed with a considerable percentage of sand.

Loam, as the term is usually understood in the Mississippi Valley, is a fine and light soil, largely sandy in composition, which seems to be nearly identical in composition with the loams of the Missouri and the bluff formation of the Lower Mississippi. In its predominant characteristics it resembles that soil strongly. Doubtless it is mostly derived from the floods of the Missouri

Of these materials, clay is the best for levees and loam probably the worst. The great advantage of clay is its resistance to the action of water, whether to the waves of the river or to the erosive effect of water percolating through holes or cavities. It also turns water better than either of the other earths. It cracks open with dry weather, so that often, in summer and autumn, long and wide fissures may be seen, running longitudinally with the levee, as if made by an earthquake. These cracks close, however, when the clay gets wet, and the embankment, if well built, becomes fairly impervious to water.

Sand is usually much distrusted on account of its permeability and looseness. It will not stand the action of waves at all, even when well sodded, and a hole or defect of any kind greatly imperils the existence of the levee. This disadvantage is partially offset by the fact that the walls of cavities in this material often fall in and stop the flow, thus giving time to work. To allow for such contingencies sand levees should be built of ample dimensions.

It has been objected to pure sand that when saturated with water it is apt to slip or slough on the back or land slope. As has been already stated, there is very little pure sand to be found in the alluvial soil of the Mississippi plain. Where it is the predominating constituent the embankments are always given a flat back slope, at least three to one, or are reinforced by banquettes Furthermore, they are well sodded, so that slips are not common unless the water should get against the levees while they are yet green. Such incidents are especially likely to happen when wheelbarrows have been used in construction. Elsewhere, serious disasters have been reported from the employment of pure sand as a material. In East Holstein, in 1872, when certain sand levees had been exposed for a long time to the pressure of water at high stages, and had become thoroughly infiltrated, the back slope sloughed away, the crown sank, and whole stretches of levee suddenly disappeared. In this instance the dikes had been constructed of pure sand from the dunes, with a pitching of clay on the water side, but the latter had been damaged by storms.

The quality of loam which renders it particularly undesireable is its lightness and the fineness and want of coherency of its particles. These qualities render it very treacherous. It is softer and more yielding than sand, and when thoroughly wet it becomes almost a mud. A levee built of this material, after the water has stood against it a month or so, may be pierced by a sharpened rod for a depth of ten or twelve feet with little difficulty. So also may the adjacent natural soil, if it be of the same constitution. Hence banks built of this sort of earth are always given extra strength.

Clay does not stand well at grade. It is always settling more or less, and it requires constant looking after and repair to keep it up to standard height. Sand and loam shrink very little and never beyond a certain point.

An extensive and careful series of experiments on earths for levee-building purposes was made in Germany from 1872 to 1877 by Mr. B. Schelten and published in the "Zeitschrift fur Bauwesen" for May of the latter year. The objects of the investigation were manifold: to determine the quantity of sand in the various earths submitted, the coarseness of the sandy particles, the specific gravity of the specimens, the proportion of carbonate of lime therein, their relative rates of shrinkage when dried, their tensile strength, their resistance to the action of still water, of running water and of rainfall, and finally their capacity for retaining moisture. The immediate impulse to these experiments was given by the failure of the sand-dikes in East Holstein previously noted, when, in Mr. Schelten's words, "the whole dyke system was annihilated and leveled with the ground."

This is not the place to give a detailed account of Mr. Schelten's experiments or of the ingenious methods employed by him. His conclusion was that it was better to incur the expense of hauling

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suitable material a long distance, even by the use of a temporary track and locomotives.

As to what constitutes suitable material, it was concluded that in point of specific gravity there was but little difference between the several varieties of earth, the greater weight of the individual particles of sand being offset by the number of voids between them. So far as resistance to the action of water, both still and moving, was concerned, it seemed to be in proportion to the cohesive or tensile strength of the material—that is, it was greatest with clay and least with sand. Capacity for shrinkage was just the other way. It was found that a moderate percentage of carbonate of lime was not injurious, but that this material afforded a stronger resistance to the impact of waves than to the gradual dissolving action of a long-continued pressure of still water.

On the whole, it was concluded that a percentage of sand as high as 45 would not render a material absolutely unsuitable. The best earths were thought to be contained within the percentages of 16 and 25, and of these the preference was given to those which had from 15 to 18 % of sand.

Usually the Mississippi River engineer has very little choice as to the material he will use. It must be such as lies in front of the line he has located, and the location is generally determined by very different considerations than that of the quality of the material

Like most alluvial soils, the Mississippi flood-plain is composed of alternating strata of various thicknesses and positions. The top soil may be clay for a foot or two, and then we may come to a sand-stratum 10 ft. deep. A quarter of a mile further on the top soil may be sand and the sub-soil clay, or either kind of earth may extend downward for an indefinite distance. Loam is always a top soil, but is of various thickness. Usually a fair idea of the distribution of the strata may be obtained by an examination of the exposures at the abraded river bank, or, in remote places, by rough borings made with a post-hole digger. It is usually considered by levee-engineers that a judicious mixture of sand and clay makes, on the whole, the most desirable levee in facility of construction and in qualities of a permanent nature. Clay is very hard to work in very dry weather, and also after rain. Sand can be worked at any time. It is very useful in assisting to make roads for the teams. It drains easily. When mixed with clay, it prevents the latter from cracking and from undue shrinkage, without too much impairing the toughness and resisting qualities of the latter.

Loam is a soil which is very easily handled by the contractor when it is dry. It "packs" very well, and stands at grade admirably. When wet, however, especially when the ground is saturated with seep-water, it is extremely treacherous, both in the borrow-pits and in the bank, and teams can hardly walk on it without "miring." It is very permeable, and is likely to slough unless the back slope be flat and well sodded.

It would be possible, no doubt, to obtain a better selection of material in each case by a longer haul, and to distribute it better in the bank by a more minute and careful superintendence and by paying an extra price, but hitherto all other considerations have been dominated by the one necessity of economy. In Holland the strongest and best material is uniformly thrown on the front slope, the weaker and less desirable being placed in the body and back of the dike. We have not yet attained to these refinements. The pressing demand for increased height of the levees as the system is approaching perfection and the confinement of the flood-waters is more nearly complete, and the scantiness of resources compared with the magnitude of the work still to be done, have made cheapness the prime consideration.

Precautions in Construction.

In building a levee the first of all precautions to be taken is to clear the ground thoroughly of all trees and vegetable or other extraneous matter. Stumps must be grubbed out by the roots, or, still better, be blown out by the use of explosives. According to the ordinary practice of contractors a hole is worked under the stump, sprung with a dynamite cartridge or two, and the mine is then charged with Judson powder and exploded by dynamite. Dynamite alone is too quick in its action and shatters the stumps. The slower explosive lifts them out and pulls out a great part of the lateral roots with them. The ground is then thoroughly denuded of all leaves and trash and well broken with a plow, so as to form a good bond with the new earth. The latter is thrown on in layers. In the latest practice, if wheeled scrapers be used, the layers may be 3 ft. thick; if wheelbarrows, then 1 ft. only, and the earth must be tamped with rammers or by riding horses or mules over it. The work must be built from the beginning out to the slope-stakes, to avoid the necessity of dressing it afterward with a light coating of earth, which is prone to slip or to wash off with the first heavy rain. According to the minute specifications of the United States engineers, the earth first taken from the surface of the ground, which is more or less contaminated with fragments of roots, grass, etc., is removed from the base of the levee and deposited in a banquette adjacent, of which more hereafter.

Levee Cross-Sections.

The usual dimensions adopted are a crown of 8 to 10 ft. and slopes of 3 to 1. In the case of sand or loam, especially if the bank be a large one, these dimensions are increased. In the instance of the Lake Bolivar Levee, in Mississippi, the crown was 15 ft. and the slopes 5 to 1, and even these dimensions were subsequently exceeded. This levee was about 25 ft. high and the material was nearly pure fine white sand. Very frequently, in high levees, the increase of strength is in the form of a banquette or "bench," as shown in the accompanying cut, placed on the land side. The dimensions of this appendage are somewhat different in the practice of different engineers. In the Lower Yazoo District it has usually a crown of 20 ft. and a slope of 5 to 1. The crown itself drops 1 ft. in 20. It is thus constructed because it is expected to use it as a roadway. The United States engineers in the Third District make the slope 4 to 1, the drop in the crown 2 ft. A better form, from an engineering point of view, is the one adopted in recent constructions in Holland, namely, with a cross-section of a long segment of a circle or other curve.

Blowing out Stumps for Levee Foundations.

In the Dutch practice, and also generally on the Mississippi, the crown of the banquette is about 8 ft. below the crown of the levee. This distance is prescribed by experience. A levee of the standard dimensions given above is weakest at its base; and the higher the levee the less the proportionate strength at the base. Thus, a levee 1 ft. high has a base of 14 ft.; of 2 ft., a base of 20 ft., or 10 base to 1 altitude; of 4 ft., a base of 32 ft., or 8 to 1; of 8 ft., a base of 56 ft., or 7 to 1; of 12 ft., a base of 6.7 to 1; of 20 ft., a base of 6.4 to 1. A banquette supplies in an economical form, the strength which is missing at the place where it is most needed. In practice it is found that levees of standard dimensions 8 ft. high or less never break.

Levee Foundations.

There is another reason for building banquettes to high levees in certain situations, and that is the weakness of the underground. No matter how good the material of the dike nor how much care has been exercised in its construction, if the natural soil on which it is placed be weak, the structure will be endangered. In fact, the foundation now becomes the weak point of the work. The levee itself, being composed of sound earth, well packed, is good and safe. The underground, however, is light and porous, traversed by roots and fibres and permeated by holes, perhaps containing cavities. It is liable, therefore, to give way to the pressure of the external water; the more so if it be composed of fine and distinct particles, each of which becomes, as it were, enveloped by the water and is carried with it, the whole assuming a semi-fluid condition. How nearly both the levee and the external soil may approximate to this state is shown by the fact previously adverted to, that in such situations a slight rod like a cane fishing-rod may often be thrust 10 or 12 ft., with little effort, into the earth.

The effect of the external pressure, transmitted through or by such a loose and weak stratum, may be to "blow up" the ground on the land side of the levee, or, roughly speaking, knock the bottom from under it.

This is not a speculative or chimerical danger, but a very real one. The five breaks which occurred in the Lower Yazoo District of Mississippi, in 1890, are all supposed to have proceeded from this cause. The accident to the St. Louis settling basins, reported in Engineering News for Oct. 31, 1895, p. 302, is an instance of this kind. A masonry wall 8 ft. thick and 15 ft. high rested on a concrete foundation 15 ft. wide, and was built on a soil of river silt composed of sand and mud. This wall separated two settling basins, one full, the other empty. Says Prof. Johnson:

> Evidently the seepage from the full basin found its way beneath the puddle in the empty basin, and raised it, with its covering of concrete, over an area of about 100 ft. sq., like a great blanket, until it burst through and washed out a hole beneath the stone wall.

There would seem to be two ways of remedying such a weakness of the foundation. One is to extend the embankment down through the permeable stratum to a solid material. The other is to increase the base of the bank, and thus diminish the hydraulic head by friction. The former expedient is usually impracticable in levee construction. The permeable stratum is generally very thick, and the expense of building a puddle wall or other water-tight diaphragm is prohibitory. If it were built without a good foundation it would be of little avail, and would be liable to settle, and do more harm than good. A slight move is generally made in this direction by the construction of what is called a "muck-ditch." This is a trench excavated near the center line of the proposed levee, filled with selected strong earth, well tamped. It is not puddled as a matter of choice, though frequently the soil water is present in such quantity as to necessitate such a process.

Different degrees of consequence are attached to muck-ditches by different engineers. In the Upper Yazoo district, in important situations, they are sometimes of great dimensions—from 12 to 20 ft. wide and from 8 to 12 ft. deep. Generally levee engineers, while they recognize that muck-ditches do a certain amount of good, as they have very limited means, prefer to spend their money above ground. They therefore give their ditches much smaller dimensions, using them, in fact, rather for exploration than for any other purpose. Very often a promising-looking soil conceals serious defects—stumps, logs, cavities left in the ground and covered up by subsequent deposits. If such are present in formidable numbers their existence will usually be made known in the course of the excavation of the ditch.

The second means of healing the defect of a weak undergound is by extending the base, as already mentioned. This is the method usually employed in Holland. Muck-ditches are not unknown in that country, but they are not much favored. They are sometimes employed in peaty ground, extending through the peat-stratum, which is usually only a few feet thick.

"What is really needed," says General Comstock, "is that the surface of the ground-water as one follows it from the river side of the levee, at the high water level, through the levee and the subjacent ground, to the ground-water surface at some distance from the levee on the land side, shall everywhere be below the surface of the levee and of the adjacent ground." The same view is maintained by foreign engineers. With the object of ascertaining the true hydraulic gradient of the ground-water, in 1892, a number of well-tubes, with points or strainers, were driven into the ground, behind the levee, and at different distances from it. The results, as reported, were very unsatisfactory. In one instance the water rose higher 150 ft. from the levee than at 50. In all it rose above the surface of the ground as far back as 150 or 200 ft., and would probably have done the same at still greater distances. A driven well has been observed, spouting water like a flowing artesian well, 2 ft. or more above the ground, at a distance of 250 or 300 ft. It is therefore impracticable to build levees with such a cross-section. More-

crossings of deep sloughs or bayous, but they are now becoming general on all levees as much as 12 ft. high, or on sand or loam levees of much smaller size. The long slope given to the banquettes has been, of course, for the purpose of covering as much ground as possible.

The slopes of 3 to 1 now generally adopted are the outcome of a long experience. In the early stages of levee building, much less dimensions were often used, but disaster was frequently the result. A steep back-slope very often leads to extensive sloughing or slipping, especially if the material be at all weak. A steep front slope exposes the embankment to serious abrasion by waves. A slope of 2 to 1 is less than the angle of repose of wet earth of almost any kind. In very small levees, where the width of the crown cuts an important figure, slopes may often be reduced. Thus, a levee 3 ft. high, with a crown of 8 ft. and slopes of 2 to 1, has a stronger section than a levee 12 ft. high, with slopes of 3 to 1.

Where the exposure to winds is very great, the front slope is often made as flat as 5 to 1, the back

construction, in another 6ft., and the settling has continued, at a decreasing rate, to the present day. In a notorious instance, that of the Vaucluse or "Whisky Chute" levee, in Arkansas, where the fill was about 22 ft., the sinking was 18 ft. or more. A great part of this occurred after the water got against the newly-constructed levee, and it took constant work, night and day, to keep up with the subsidence. The levee was saved after weeks of heroic labor. Since that time the settling has been comparatively small. This was an extreme case, the foundation having been the bottom of a lake within a few years, and the crust of recent deposit very thin. Sometimes the bottom is hard and the settling comparatively small.

It has been proposed, in such cases, to put in pile-foundations, sand piles, mattresses and timber-grillages, and indeed several of these expedients have been tried. The results of the experiments, on the whole, have not been satisfactory. Piles are expensive and perishable. If they rot, as they are likely to do in such situations, they may make the matter worse than better.

LEVEE CONSTRUCTION WITH WHEEL-SCRAPERS.

over there is thus allowed a margin which is unnecessarily great for the purpose of safety.

The extension of the base in Holland is usually effected by the means of banquettes, either on the land or the water side or on both. If there be only one, it is on the land side, if practicable. Some of the Dutch dikes are built on very bad soil. The dike on the northern side of the Lek (the northerly arm of the Rhine) which protects South Holland and Utrecht, the country of the deep polders, is built on a very leaky and treacherous foundation. It is also considerably above the average height. Consequently the levees are reinforced by strong banquettes throughout the whole line. The worst of all locations, however, is that of the New South Linge-Dike. The crown of this great work is some 18 or 20 ft. above the level of the surrounding country. It is built on very loose and porous soil, and it is known to have broken once. It is, therefore, strengthened in an extraordinary manner by banquettes, both internal and external, sometimes 75 or 100 ft. each in width.

A similar practice has been in vogue for many years along the Mississippi. Formerly banquettes were used only in exceptional situations, as at the

slope being then reduced to 2 or 2.5 to 1. It is found that a flat slope is a great protection against the wash of waves, and that a well sodded "buck-shot" levee, with a slope of 5 to 1, will stand a pretty stiff wind. If the sod be once cut through, however, and a hole made in the clay, the latter is liable to be undermined, and the superincumbent masses of earth fall in huge blocks.

Very often the engineer has to cross, with his levees, the beds of actual or former water-courses. He will avoid such a location if he can; if not, he will make his crossing as short as possible, and will select his place with great care; for he knows that his levee will be likely to sink more or less during construction or afterward. Sometimes the bed of an old lake or bayou has been almost obliterated by recent deposits, and has been converted into arable land, so that the existence of the old formation is unknown or forgotten. The embankment will sink all the same. In one case, within the experience of the writer, a levee built across such an obliterated and forgotten lake-bed sank, during construction, 2 ft. for a distance of 3,000 ft., and continued to settle slowly for a long time. In another the sinking was more than 4 ft. during

Sand-piles have been recommended but never tried. So have timber foundations. A mattress-foundation was tried at the crossing of Lake Bolivar, in Mississippi, but it gave a great deal of trouble by leakage under the levee, and seriously imperilled for a while, the existence of the latter. On the whole, it has been found best to rely on earth alone, and to keep piling it on till it reaches equilibrium. In Holland, where they have the same difficulties, they have reached very similar conclusions.

Diaphragms of timber and walls or cores of cement have been tried in levees to a limited extent, with the double purpose of preventing leakage through the bank and under it, and also to afford an obstacle to the ravages of boring animals. They have never met with any extended use. For the embankment pure earth is good enough, if it be properly put up. As a means of preventing leakage *under* the levee they might be useful adjuncts were it not for their expense and perishability; but their effect would be limited, and after all it would still be necessary, in most situations, to have a broad base. The necessity for the later compels the adoption of ample dimensions for the bank it-

self, which is therefore made stronger than mere hydrostatic considerations might dictate.

The Height of Levees.

To establish proper grades for a new system of levees would require considerable skill and experience. Where a line has been in existence for many years and has to be enlarged or a portion of it rebuilt, the task is much simpler. In all great floods the high-water marks are taken with great care, at as many different points as possible, and the grades are usually fixed with reference to these elevations. The provisional grade now generally adopted is 3 ft. above the highest known flood. Now within the last 14 years there have been several great floods. The heights attained by them were in nowise proportioned to their respective magnitudes. The greatest of them was in 1882. In that year, however, from one-fifth to one-half of the discharge passed outside of the channel of the river, in the basins and lowlands, so that the heights reached along the lines of levee were not as great as were subsequently attained by other floods of less magnitude but more closely confined. In 1886, for instance, the river reached its greatest height at Helena; in 1890, from Helena to the mouth of White River; in 1893, from Arkansas City to Lake Providence; in 1884 and 1890, at Vicksburg.

These diversities are principally due to the reclamation of tracts by new levees, to breaks in the levees already built and to return-flows at the lower ends of the several basins from breaks along their fronts. The principal epochs in levee-building are the closure of the upper end of the Yazoo Basin in 1884-5, the rebuilding of the Arkansas levees in 1887, the approaching completion of the levees of the White River Basin during the coming year, and the partial and rapidly-progressing construction of the levees of St. Francis Basin. During every great flood, so far, there have been crevasses in one situation or another, so that the high-water line has never been regular, but has been vitiated by these perturbations. Attempts have been made to establish what has been called a "potential high-water line"—that is, a line which should represent the heights to be attained if the river had been entirely confined. Such attempts, however, have been only partial and have been based on rather uncertain data, and the methods pursued have not been rigorously correct.

Even in the case of a perfectly confined river the high-water line is very irregular. Along the line of the Lower Yazoo District the average slope is about 0.36 ft. to the mile. This slope, however, is very irregularly distributed. From Station 0 to 480, it is 0.12 ft. to the mile; from 480 to 620 it is 0.53 ft.; from 620 to 870 it is 0.15; from 870 to 1320 it is 0.53, etc.

These remarkable variations are due mostly to changes in the alinement of the levee, owing to the tortuous course of the river. Where the course of a river or the trace of a levee makes an abrupt turn, so as to bring it sharply across the line of its former direction, the water is approximately "ponded" for a considerable distance—frequently for several miles.

In many situations the river runs next the bank during low water, but in floods seeks a shorter route across the points of bars or through secondary channels in the middle of the stream or next the opposite shore. In such cases the late low-water channel becomes nearly a pond, and the slope next the bank may be very small. In a given instance the high-water mark, in such a location, varied but one-tenth of a foot in six miles. These level reaches are soon compensated by a very rapid fall—sometimes a foot to the mile or more. In fact, the flood-line is a succession of flat and steep slopes. Below a strongly projecting salient there is frequently an abrupt drop in the high-water line of 2 ft. or more.

Disasters have been known to result from inattention to these facts. In one instance a levee several miles in length was built with the average fall in grade of about 0.4 ft. to the mile, when it should have been built, in that situation, to level grade. Consequently the water ran over it at the lower end, while it was still 1.5 ft. below the crown at the upper end.

Methods of Construction.

After the completion of the work the levee is carefully sodded with tufts of Bermuda grass. This is a jointed grass which puts out lateral runners, like a strawberry vine, and under favorable circumstances rapidly covers the ground. It grows best in loamy soil, or soil with a moderate proportion of sand—not well in pure sand or in pure clay. It needs moisture to start it properly, but after it is well matted it will stand drought, freezing or submersion for weeks. With a flat slope, in moderately strong soil, it is a good defense against the wash of ordinary waves. With sandy material it affords protection against rain, but not against even moderate storms when there are no woods or other cover in front of it.

As to methods of construction the preference is generally given to wheeled scrapers, especially if it is expected that water shall get against the new levee immediately. Generally, if it be possible, the levee is built a year or so earlier than it will probably be needed, in order to give it time to settle thoroughly and to be completely covered with sod. With certain kinds of soil there is an objection to scraper-built levees, namely, that they are very liable to be cut and washed into gullies by rain before the sod has had time to grow. These soils are loam and mixed sand. When put up with wheelbarrows, banks of such material are at first comparatively loose and porous, and absorb water like a sponge. By the time they have settled fully, the sod has grown. When the earth, however, has been put up with scrapers, it is very hard, and sheds water like the roof of a house. The material being light and friable, the rain soon cuts channels which it uses regularly, and the gullies which are the result of this action sometimes cut almost through the crown of the levee. A slope thus eroded has to be re-dressed before it is sodded, and the new dressing is liable to be washed away also. In spite of this objection, scraper-built levees are generally preferred, and some engineers place such restrictions on wheelbarrow-work as almost to prohibit it.

The shrinkage exacted is generally one-fifth for wheelbarrow-work untamped, or one-tenth if it be tamped, and one-tenth for scraper-work.

All material is taken from the front or river side, if it be economically possible. The berm on the water side is usually 30 ft. The borrow pits must not be more than 3.5 ft. deep next the levee and 4.5 or 5 ft. next the river. If it be necessary to get material from the land side the pits must be distant 80 ft. or more from the inside slope-stakes.

Letting Water Against New Levees.

In the practice of the Louisiana engineers, when the old levee is still standing, and when there is a probability of the water getting against the new embankment, the old levee is cut in several places and the water let against the new bank gradually. Otherwise, if a large section of the old levee should cave away suddenly, it is said there might be a violent rush of water against the new work, subjecting the latter to a sudden strain and to the attack of strong currents from the whirling action of the inpouring torrent, and giving no time for the repair of leaks or other defects which might be discovered.

Elsewhere the engineers generally prefer to have two strings to their bow and hold the old levee as long as possible. In one instance at least, within the writer's knowledge, a levee was lost from a rush of water against it, but the exact cause of the break was unknown. The two levees were pretty close together. The new work had been built with wheelbarrows, untamped, and was said to have been very loosely put up. Whether it was overwhelmed by the rush, eroded by the force of the current, or simply because it was too loose to hold water, is not known. The last supposition seems to be best supported. Generally, when the old and new levees are a safe distance apart, say 1,000 ft., and when the new work has been built according to the specifications now in use, there seems to be little risk in holding the old levee till it breaks of itself. As an exception, if there be a long line of large levee close to a badly caving bank, so that it is possible for several hundred feet to go into the river at once, it might be more prudent to cut it.

Seep-Water and Its Dangers.

The measure of protection afforded by a levee to the lands behind it, though the embankment be sound and tight, is not complete; for the underground is still loose and porous, and transmits a certain quantity of water, which may be exceedingly inconvenient, damaging and even dangerous. When the flow under the levee is diffused among a number of capillary tubes, it may be harmful to the adjacent lands, but it will not seriously threaten the existence of the levee, if the latter have sufficient base to keep it from "blowing up." There are frequently cavities under a levee, however, of formidable proportions. Loamy soils are very apt to have considerable cistern-like voids, caused by the settling of the light material under the influence of water infiltrating it, or by its subtraction through pores and holes and the falling-in of the walls of the cavities thus induced. It is a well-known peculiarity of this earth, as of the loess from which it is derived or to which it is related, that it stands at very steep angles, indeed, vertical or even undercut, without falling in. Consequently cavities, when they form, are not filled by the caving-in of the superincumbent earth, as happens with sand, but remain and even enlarge.

It was not formerly the custom to grub out or blow out stumps. They were merely required to be cut down as nearly as possible to the level of the ground, and this requirement was not always strictly enforced. Even under the present specifications, it is not possible to get out the lateral roots, except such portions of them as may come out with the stump when it is blown out. Consequently, even in the new levees, and still more in the old, there were left in the ground considerable quantities of woody and barky matter, which eventually decay and form large conduits for water under the base of the embankment.

As a result of these and perhaps of other causes, it is very common to find holes near the inner slope of the levee, which at flood-time spout considerable volumes of water. These are regarded as dangerous or not, according to their size, their violence, the nature of the soil through which they pass, their condition, whether stationary or increasing in flow, the character of the water which they discharge, etc. If the hole be small, in strong clay (buckshot) soil, if the flow be not violent, not increasing, the water clear, it is not regarded as formidable. If it be in sandy or loamy soil and discharging river water, or, still worse, muddy water, it must be looked after at once. In the former case it is evident that the water flows through a number of pores so small as to filter it from even the quantity of sediment that it carried while in the river. In the latter, it is coming through holes of larger size, has probably a straighter and shorter course to traverse, and is continually enlarging its channel.

Very often there occur violent outbreaks of water through the natural surface inside the levee, carrying with them large quantities of sand, which is distributed around the circumference of the hole exactly as ashes and cinders are deposited around the margin of a volcanic crater. If these

Section of "Sand Boil."

eruptions continued long at the same rate, they would be extremely dangerous; for they would soon form extensive cavities under the levees. They generally "choke up," in common parlance, however, and cease to discharge solid matter. Water continues to bubble through them in a fitful and intermittent manner, and to the superficial observer it seems as though they were discharging sand, but they are not. They are merely tossing up the coarser particles retained inside the crater, which immediately fall back again; and the water flows off clear. These eruptions are locally called "sand-boils."

It is the opinion of many intelligent observers that the water which flows from these holes must have been derived from an infinity of small channels; otherwise its velocity would become destructive, and the cavity would keep on enlarging till a break occurred. On the other hand, the manner of occurrence seems to indicate that at the beginning of the outbreak there was a strong head concentrated in a single conduit, which was afterwards closed by the falling in of its walls, the place lately occupied by water being now filled, to the depth perhaps of many feet, with sand. These

holes are always nearly vertical, so far as they have been explored. It is not generally known from what depth they proceed.

Holes are sometimes found in the levees themselves, from unknown defects of construction or from the scouring effects of long-continued percolation through loose material. They are very dangerous, and should always be checked as soon as discovered.

It has often been supposed that boring animals are largely responsible for the existence of the holes found in and under levees, and indeed these go popularly under the name of "crayfish-holes." It is true that crayfish are generally found in them. So general is the belief that they are the makers of the holes and consequently the authors of the mischief that arises from the latter, that the Irish laborers who work on the levees cannot be persuaded to kill a crayfish. "He's the poor man's friend," they say; that is, by causing breaks in the embankments he gives work to the laborer in repairing and rebuilding them. Doubtless there are some parts of the Mississippi Valley in which boring animals are formidable enemies to the levees. In the strong clay soil of Lower Louisiana it is said that muskrats, beavers, fiddler-crabs and crayfish have caused serious breaks. One bird even, the kingfisher, has been detected in boring holes horizontally into a levee. One of the holes was 8 ft. deep.

From whatever cause, the water which percolates through the soil, the "seep-water," as it is called, is a serious injury to the planter. Overflow-water brings with it some of the elements of fertilization. Seep-water has been deprived of all these by filtration, and has, perhaps, taken up others, by solution, which are positively detrimental. M. Barois tells us that in Egypt they never use ditch-water for irrigation, but only such as is derived directly from the river; because the former, in its passage through the pores of the earth, has absorbed alkaline and other matters which render it injurious to the crops. It is certain that in the Mississippi Valley seep-water is regarded as far more hurtful than rain-water. It is very hard to get rid of it by ditching. If the flood comes early in the season, it may go out of the ground in time to make a crop. If the flood come late, the seep-water will kill whatever it touches except grass, and then it will be too late to replant.

The influence of seep-water, however, does not extend very far from the river; and as it does not injure Bermuda grass, the riparian lands may be used as pasture or meadows.

Care of the Levees in the Flood Season.

The greatest care of the levee engineer is the maintenance of his dikes during high water: if, indeed, he be so unlucky as to have them in charge. In Louisiana, high-water work is entrusted to the police juries of the several parishes, under the superintendence of the State Engineers; but in Mississippi the latter have the whole control and responsibility: they organize and pay the forces, and everything is done under their immediate orders.

The floods of the Mississippi proceed either from the Ohio and its tributaries or from the Upper Mississippi and Missouri jointly; or from all together. They may culminate, at Cairo, at any time from February to June; indeed, there was once (in 1875) a considerable flood in August. They may be powerfully aided by freshets from the St. Francis, White, Arkansas, Yazoo and Red.

The rises of the Ohio generally reach their highest stage at Cairo in February or March; from the upper Mississippi and Missouri, in May or June. The great rises of 1882, 1883 and 1884 proceeded mainly from the Ohio, and culminated at Cairo during the last days of February. In the first, 69% of the discharge which passed Cairo at the top of the rise came from the Ohio; in the second, about 70%; in the third, about 85%.

On the other hand, the discharge which passed St. Louis in May, 1892, was 74% of that passing Cairo. In 1858 there was about the same proportion.

Frequently there are dangerous floods arising from the coincidence of late rises from the Ohio and early freshets from the upper Mississippi and Missouri. These usually reach their greatest height at Cairo in April or May.

The March rises are very formidable, not only on account of the great volume of water which they frequently bring down, but from the high winds which are so apt to prevail at that season. The cyclonic storms which bring the principal part of the heavy rainfall during flood years are usually attended or succeeded by strong gales. Before and during the passage of the center of the storm the winds are from the south or southwest; after the passage of the center and during the "clearing up," from the northwest or north. The latter are usually very cold, strong and persistent, and are often accompanied for a time with sleet, rain or snow. The levees on the Mississippi side, from their westerly exposure, are peculiarly vulnerable to the attacks of these winds. Easterly winds are seldom formidable from their strength.

The winds which occur in April are mostly southwesters, but blow with considerable violence for days together. Those of May and June are more fitful, their paroxysms seldom lasting more than half an hour or so. None of these have the strength and persistency of the March winds, and they are mild in temperature.

The difficulty of defending an exposed levee against a heavy storm is sometimes very great, even where the material is strong clay. Where the bank is composed of sand or loam the task is still harder. There are long bends of the river where the wind has a sweep up or down stream of several miles, and pretty heavy seas rise, which break against the front slope of the levee like surf on a sea beach, or dash clean over it, throwing logs or other debris to the ground below. The waves are much higher when the wind is blowing up stream, or else where there is no current at all, as in the "old river lakes" left by cut-offs.

Methods of Storm Protection.

In such cases untiring and systematic work is necessary to save the levee from being cut in two or from being washed away. The remedies employed are temporary revetments of plank, rails, timbers, cotton stalks, the refuse of sugar-cane or sacks filled with earth. Bagging, such as is used for covering cotton bales, is sometimes recommended, but is not effective in time of real danger.

Revetments are generally applied after the waves have already made a cut in the front slope, and there is a nearly vertical wall of caving earth. In very exposed situations, permanent revetments of plank are frequently constructed. For this purpose, 6-in. posts are firmly set in the ground about 4 ft., about 6 ft. apart, a little in front of the

Protecting Crown of Levee against Waves with Light Sacks.

vertical wall of earth, which is dressed off as far as may be necessary. The posts are anchored at the bottom by cleats nailed crosswise. Behind the posts (that is, next to the earth), horizontal courses of sound heart-plank are nailed, lap-streak or clinker-wise. The bottom plank is set into the ground about 10 ins. Joints are carefully broken. After the revetment is finished, strong earth is filled in behind it and lightly tamped. If it be tamped too heavily, it will spring the plank. Such a revetment costs about $3,500 a mile, and will last without repairs about six years. Sometimes lighter posts are used, only 4 ft. apart, and should be braced back to heelposts in the crown of the levee, as in the figure.

Temporary plank revetments, for high-water purposes, are built on the same principles, but more hastily and cheaply. They are liable to be undermined by the waves, especially in sandy

Plank Revetment.

soils, in which event the lost earth must be replaced by sacks filled with clay or the strongest soil available. Sometimes plank are driven perpendicularly into the levee, like palisades, and nailed to stringers fastened to the posts.

All sorts of rails, brush, stalks or refuse may be used in emergencies by placing them horizontally behind vertical stakes. The difficulty about such materials is that they are not to be had in sufficient quantity, except by a great deal of hauling, at a time when hauling is very heavy and by expenditure of much valuable time. Usually the grand resource of levee engineers for "high-water fighting" is sacks.

These can usually be had in any quantity by ordering in time. They must be sound and new. For levee purposes they are used mostly of two kinds, centals and Dundees. The former generally cost 4 or 5 cts. apiece, the latter about 8 or 10 cts. For general purposes the smaller size is preferred, as the sacks are much lighter and easier to handle. For very bad cases the larger sacks are employed as, when once placed, they are very stable.

The expert high-water foreman who is confronted with the task of holding a levee in the face of a severe storm will generally divide his men into squads of three—one to hold the sack while the others fill it. As soon as the sack is filled it is carefully sewed up and placed in position in front of the caving wall. The sacks are laid by expert men, in regular courses with much care. The men have to stand up to their waists in water, which, in February or March, is very severe work, so they must be frequently relieved. In bad situations the sacks are all placed as headers, the butts outward, or toward the river, the courses breaking joints and with a decided batter. Where the exposure is less, the soil stronger or the season more favorable, the sacks are often laid as stretchers, or the bottom course are headers and the top courses stretchers. In very light cases the sacks are sometimes placed on end in a single row.

The earth for filling is taken from the levee itself by paring away and dressing the broken and caving front slope, thus making use of the material which would otherwise be washed away. Earth should never be taken from the back slope, if it can be avoided, because the sod of the latter is essential to protect the slope against possible overfall if the water should run over the levee.

With plenty of sacks, and a well-organized and well-equipped force, a competent high-water foreman will hold a sound levee of standard dimensions against anything short of a hurricane. Of course the improvised revetment will be damaged from time to time by the inroads of the waves. If the earth with which the sacks are filled be sand it will be washed out of them after a while, and others must be put in to supply their place. Frequently the force of the waves or of the undertow will bodily lift sacks and carry them away, especially if the courses have not been well laid. Such losses must be immediately replaced. The necessity of great care in construction is apparent.

This sort of work is expensive, costing, in the worst cases, $2,000 or so a mile for construction and maintenance throughout a high-water campaign. It may be thought that it would be more economical, in the long run, to build more permanent defenses, such as the plank revetments just mentioned. There are several reasons why it would not.

First, it often happens that several seasons occur without any flood of sufficient consequence to endanger the levees. From the flood of 1844 to that of 1849 there were four intervening years of low water. From 1851 to 1858 no serious floods are recorded. From 1867 to 1874 there were six years of low water. From 1876 to 1882 there were five low

water or medium years. A revetment that lasts only six years might therefore be available for only a single flood.

Second, even in flood-years, the expense of high-water protection is very seldom as great as has been mentioned. Generally, even in exposed places, it is not more than one-half of this. The exposed places constitute perhaps one-fifth of the whole line.

Third, the danger-point is often shifted, so that in two or three years the levee that was lately in jeopardy has become comparatively safe. This generally arises either from the ordinary progression of bars down-stream, covered with a growth of willow and cottonwood, which protects the lately exposed places; or else from the spontaneous springing up of such a growth on the foreshores, enriched as they are with silt, and full of the germs of vegetation.

Fourth, the levees are in a state of very rapid transition, progressing from a very immature stage toward perfection. Consequently they are overhauled every two or three years, rebuilt or enlarged. This sometimes involves the removal and replacing of the revetment, which is almost as expensive as the original construction. Levees are caved into the river and others built at a safe distance behind them. It is not worth while to construct permanent expensive works under such conditions.

There are many other uses to which sacks can be put in high-water work. They are often unnecessarily and wastefully employed. There are some cases in which they are actively detrimental and dangerous. Hence great discretion is necessary in handling them. About 400,000 of them were used by the Lower Yazoo District in the flood of 1890.

There are other devices which have occasionally been used to protect levees against storms. Breakwaters of timber, outside of and disconnected from the levee, have been tried, but they will not stand the racking they are subjected to. Floating booms or rafts are tolerably effective if there are suitable opportunities for anchoring them. A thick belt of small timber is an excellent breakwater. A thin belt of woods is of little use, and the presence of an ordinary grove of large trees is no protection at all. In a given instance, where the emergency was great, the trees were felled so that their trunks lay parallel to the levee and were anchored to the stumps. The boom thus formed greatly reduced the height and force of the waves, and the breakers were transformed into rollers. It has been proposed to anchor bags of waste soaked in oil outside the levee. This plan is worthy of a trial.

Leakage of Levees.

While the danger from storms is the most serious one that the levees are exposed to, it is by no means the only one. The leak-holes, or "crayfish-holes," previously described, augment visibly in violence with every half-foot of rise, and in time of great floods they often assume very formidable proportions, spouting water in considerable volumes and to a height of half a foot or more. As long as they spout clear water and are not very large they are merely watched. If they become

Hooping a "Sand Boil."

dangerous, in the opinion of the inspector, they are usually "hooped," as the expression is; that is, a small semicircular levee is built around them and the water allowed to find its level in the little basin thus formed. The "hoop" is usually built to a height about 2 ft. less than that of the river-water, and if the water in it rises high enough to threaten to overflow the margin of the hoop the overflow is conducted off by a trough. It does not usually rise so high, the head being diminished by leakage and seepage. If the water-level in the hoop were brought up to the same height as that of the river the pressure would simply be transferred from the main levee to the hoop, which is not desired. What is sought is merely to relieve the levee from a part of the strain and to deaden the current of the water passing through the leak, so that it shall not have power to cause further erosion and enlarge the hole or to "burst up" the surrounding ground. If the entire pressure were transferred to the hoop it would tend to produce this very evil.

If the origin of the hole on the outside can be detected it is generally stopped without much trouble.

The "sand-boils" previously alluded to are very common and very alarming incidents of every high water, and are especially prevalent since the great accessions which have been made in recent years to the height of the levees. At their first occurrence a stream of water suddenly bursts through the ground, throwing out large volumes of sand several cubic feet or perhaps even yards, which it distributes around the circumference of the hole as already described. Sometimes large numbers of these outbursts occur in the same locality; indeed, there are some situations which are peculiarly liable to them. Twenty or 30 will be found in a length of 200 or 300 ft. They do not usually occur very near the base of the levee, but 40 or 50 or 100 or 200 ft. away; indeed, they are occasionally found 1,000 ft. distant from the levee. In a given instance a large number of them occurred in a borrow-pit which had been dug (from necessity) on the land side of a levee, and threw out so much sand that they filled the pit in places to a depth of nearly 2 ft. This was in a loam or loess soil.

The material thrown out by these eruptions leaves cavities somewhere under or near the levee. In a few instances a sinking of the ground has occurred in close vicinity of the "boils," showing, plainly enough, that a void had been created near the surface, which had been filled by the falling-in of the top crust. In most cases there is no clew to the locality of the cavity. It may be deep or shallow, outside, under or inside the levee.

When the boil is near the levee and of considerable dimensions it is unquestionably a symptom of danger. Perhaps a little more, and it would have been a crevasse. Where it is remote the chances are that the cavity is remote also.

These ugly phenomena are seldom seen at the time of outbreak. When they are discovered it is usually too late to do anything in the way of prevention or abortion. By that time the water is quietly bubbling through the sand, and discharging over the rim of the crater in a thin, clear stream. When the manifestation is formidable, as in the instance lately cited, the remedy that suggests itself and that is generally applied is to weight down the weak place with an additional load of earth, which is usually laid upon a thick layer of brush, to allow of partial drainage of the leak-water and to prevent the contamination of the new and dry earth by the mud of the old. In one case, when the boil was seen at the moment of outbreak, the same remedy was applied. A layer of brush was immediately placed upon the bubbling and seething mass, and sacks quickly filled and thrown upon it until a force could be brought to work upon it systematically. In another case, where the berm of the levee showed a disposition to "bulge up," doubtless an outbreak was prevented by loading the berm with a thick layer of earth.

Usually the boils are too far from the levee to be hooped. Indeed, these troublesome sores have to be handled with a great deal of judgment. If they are too promptly and thoroughly suppressed, there is great danger of their breaking out elsewhere, perhaps nearer the levee, and with an additional eruption of material.

Singular as it may seem, it is not known that sand-boils have ever been the cause of a break—perhaps because when they were discovered the imminence of the danger was past. They are indeed but rudimentary or abortive crevasses, and if they do not cause disaster at the start, they are not specially likely to do so thereafter. In fact, they may be considered as partial safety valves.

After the decline of the flood, places which gave such evidences of weakness are strengthened by banquettes, etc. Often they are explored by digging, but generally without detecting the cavity. When old borrow-pits are suspected of having any connection with the outbreak, from undue depth or proximity, they are filled up.

Very dangerous and insidious are leaks in the levees themselves through the body of the embankment. The causes of their occurrence are generally mysterious. Sometimes (though very rarely) it is from faulty or fraudulent construction —the putting of an empty barrel or box into a bank, or the building of a crib or pen of logs, and covering it with earth. Such tales are told of the past, but under the rigid supervision of the present day there is no place for them. Sometimes it is from unequal settling of the earth, imperfect compacting of layers, bad joints at the meeting of two different pieces of work, or what not. If, by any means, a cavity be formed in the interior of a levee, with communication with the inside or the outside or both, it is likely to enlarge by the falling-in of the walls; and eventually it may become so great that the levee is a mere shell.

Fortunately it is generally discovered before it has reached this point. The first manifestation of it is probably a little trickling leak on the inner slope of the levee, near the base, with a sluggish flow of slightly discolored water. It is the latter circumstance that attracts the attention of the engineer or inspector. A "muddy seep" is always suspicious, no matter how insignificant the flow or how small the turpidity. Search is made on the outside for the source of the leak. Frequently it can be found. The vigilant inspector reports that "it only began yesterday evening;" therefore the water of the river has just risen above the external orifice. If so, so much the better, for it can be the more easily stopped. If not, it had better be hooped at once. In the high-water season of 1893, in the Lower Yazoo Levee District, no less than nine such leaks were discovered through the levee. In one case a very small and insignificant-looking hole was hooped. During the first day thereafter the water rose in the hoop only a foot or two. Next morning the inspector reported that "something must have given way in the night," for the hoop was filled to overflowing with muddy water. After the river had fallen the levee was cut open and a large cavity found.

Sloughing of Levees.

There is no incident of high-water work that is more alarming to the novice than the sloughing or slipping of the inside slope of a levee, with the water standing high against the outside. This is an accident that frequently happens to green levees, especially if built with wheelbarrows and without tamping. It is also very likely to occur where old levees (especially leaky ones) are enlarged on the land side. The water leaking through the old bank infiltrates the new earth, and it sloughs away bodily, forming a pasty quagmire half-way or more down the slope. Indeed, it sometimes happens with old levees, especially if the back slope be too steep.

While this would be a formidable evil if unchecked, it is one that is usually not difficult to remedy if men, tools and materials are at hand. It does not take much to arrest the motion of the sliding earth and hold it in place; and wet earth will do almost as well as dry if you can make it preserve its shape, and keep it from running away. A few stout stakes, braced back, if necessary, to a second or even a third line, will generally hold the sloughed mass in position. For this purpose brush, poles, rails, or anything, must be laid horizontally in front of the stakes to catch the earth and stop its movement. In order to fill the void left at the top of the levee by the slipping of the back slope, a good thick dressing of brush is laid on the sloughed material, and then fresh earth thrown carefully thereon till the section is restored to something like its former shape. Care must be taken that the load of new earth shall not be so heavy as to cause a new slough. When the slip is of a new enlargement on the land side of a leaky levee, it is often necessary to put in a brush-drain to carry off the leak-water.

This is one of the cases in which sacks, injudiciously used, may be positively detrimental and even dangerous. The natural impulse of an inexperienced man is to throw upon the sloughed surface all the material that he can to supply the loss, and usually this is in the form of heavily-loaded sacks. Such a process always results in making the slough still worse, and has sometimes ended in actual disaster.

In Louisiana it has long been the practice to stop sloughing by throwing earth into the water on the front slope of the levee. This process is tedious and wasteful. It costs several times as much as the Mississippi plan, and is no more effective. The latter has never been known to fail.

(Concluded on page 77.)

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The Jersey City water tangle has had another knot tied in it within the past few days. Following close upon the announcement that the East Jersey Water Co. could furnish only a small part of the temporary water supply which had been counted on, comes the decision of the State Supreme Court of New Jersey to the effect that the contract awarded a few months ago for a permanent supply is invalid. The decision mainly centers round the brilliant arguments of some of the Jersey City officials to the effect that the Jersey City Water Co., to whom the award was made, was the lowest bidder because it offered larger storage capacity than its competitors. The court, however, does not base its decision on the engineering fact that reservoir capacity alone, without regard to rainfall, drainage area and run-off, is no basis for comparing bids, but on the simple principle that competitive bids are farcical unless made in compliance with definite specifications. The city, it is said, will take the case to the Court of Errors and Appeals. Even if it should not do so, it seems that the Jersey City Water Co. may, and, moreover, that it has three years' time in which to do so.

With the contract for a permanent supply declared invalid and the temporary supply just introduced by the East Jersey Water Co. a partial failure because of the deficient carrying capacity of the Newark pipe line, the people of Jersey City are thrown back to their position of years ago—that is, they are still dependent on the sewage-polluted Passaic for their water supply. The condition of the city is even more deplorable than before, for the river grows worse as time goes on. The local authorities have failed repeatedly in their attempts to get pure water, and property-owners and leaseholders are despairing of relief and looking elsewhere for investments and homes.

The present state of affairs is due very largely to the attempts, which have thus far been successful, of a powerful water syndicate to thwart all plans for a new water supply not in conformity with its schemes of absolute monopoly of the highland waters of northeastern New Jersey. The authorities of Jersey City, whether ignorantly or wilfully, have repeatedly lent themselves to these schemes, and with such results that either they dared not award contracts, or awards made have been upset because of their non-compliance with the simplest principles of law, business and common sense. Competent engineers, and able and disinterested lawyers as advisers, have been shunned from first to last, lest these should set forth the proper course to pursue and upset years of scheming and promoting.

The people of Jersey City pay the penalty. The citizens of almost any other community, at least outside corporation-ridden New Jersey, would rise up as one man and demand pure water and intelligent business methods, instead of corrupt political measures to obtain it.

Unfortunately Jersey City does not stand alone as a sufferer and possible victim of the water monopoly of the State. Other communities are either already on the rack, or will be at no distant day, if there is not a general arising to assert the State's sovereignty over public streams and lakes of New Jersey. Year after year the water syndicates and their strong political allies have baffled all attempts to put the waters of New Jersey under State control, even in the matter of the prevention of their contamination. A bill has already been introduced in the present session of the Legislature which is designed to effect this end. The people of Jersey City would do well to examine it with a view of determining whether its passage would afford them relief. If so, they should rally to its support, and if not should try some other means of effecting that end. But legislation will not bring pure water. Doubtless the latter might have been had long ago if Jersey City had gone about securing it as almost any other city in the United States would have done, instead of avoiding competent engineers and placing itself wholly at the mercy of the water syndicate.

Of the various societies of railway mechanical men which have been organized within the last few years, none has seemed to us to promise more benefit to the railways than the little club of railway signaling engineers organized in Chicago less than a year ago under the name of the Railway Signaling Club. Starting with a membership of six in March, 1895, this club has grown to a membership of about 30, nearly all men connected with railways entering Chicago, and all of them practical signal engineers. Financially the club is solvent, but the small membership and low dues of $2 per year have limited its expenditures to the bare necessities of existence. The work the club has done has been of high character, considering its limited means and small membership, but had it not been for a few of the leading railway papers it would have been almost unknown outside of the little circle of members able to be present at each meeting. This condition of affairs has worked in the old manner well known to those who have watched the early struggles of other railway clubs, to make many of the members dissatisfied with the results they are getting from their membership, and finally the question of reorganization and remodeling the club has become apparently a vital necessity to its further development and usefulness.

There should be no two opinions about the desirability of keeping this club alive and promoting its growth, "to the end that signaling practice may be systematized and improved," as its constitution declares its efforts are to be directed. The rapidity with which signals are being introduced on our railways and the manner of their introduction have combined to bring about a troublesome lack of uniformity in construction and operation. Up to within a few years, the methods of installation and operation have been directed solely by the companies manufacturing signaling apparatus, and naturally these methods differed with each company. Recently the railways have been appointing special engineers to take charge of signaling on their lines, and these men, being educated in different methods of practice and sometimes with very little education of any kind on the subject, have done but little to better the lack of uniformity characterizing the regime of the signaling companies. We are not of the opinion that the efforts of the railways or railway clubs alone can be depended upon to bring about the general use or uniformity of use of any device for safety, but the work of the two great railway motive power associations has shown that the work such organizations are capable of in this direction is very great. A club of signaling engineers should be able to do as much and should be supported in its efforts.

The work of placing an organization like the Railway Signaling Club on a basis to do unbiased, scientific work is not simple. The danger on the one hand of driving away the commercial or trade element so desirable to the financial success of the society, and on the other hand of letting this trade element become too dominant in the affairs of the society, always act to make the work of organization and management a delicate one. There are three sources from which to draw the membership of this signaling club: First, the signaling engineers employed by the railways; second, the various engineers and officers of the signaling companies, and third, the men of engineering training not engaged in signaling work, but interested in it enough to pay their dues and aid the work of the club. Each class of men has its value to the club, and it is a mistake to exclude either class from membership. It may be desirable to restrict the privileges of one or two of the classes, but even the necessity of this is not so great as it is some times thought. The great fear seems to be that the so-called "supply-man" will use his privilege of debate to further his private interests and bring discredit on the club. This was true to some extent a decade ago, but it is not so true now. The modern supply-man is altogether too shrewd a fellow to make himself an undesirable attachment to a club or a nuisance to its members. This is not mere surmise. One of the most progressive of our railway clubs has for over a year allowed supplymen all the privileges accorded to any member, and we have yet to learn an instance in which this privilege has been abused. We have dwelt somewhat at length on this point, for, if our understanding is correct, the sentiment of some of the members of the Railway Signaling Club is a little extreme against supplymen having much participation in the affairs of the club, and we believe there is a danger in this attitude without any corresponding gain to the club. The crying need of nearly every railway club in its infancy has been adequate funds, and the supply-men have always been prompt to aid in this respect without asking much return from the club as a Club. The present need of the Railway Signaling Club is to get upon such a basis financially that its papers and discussions can be printed and made available for permanent reference by the members. If widening the scope of membership will do this, it ought to be widened.

A new development of the rapid transit facilities of electric railways is in the line of providing special private cars for the use of theater parties, picnic parties, etc., and cars for this class of service have already been introduced in Brooklyn, N. Y., as described in another column. For theater or skating parties, the car will leave a special point, where the party will assemble at a stated time, and until the time set for returning the car will wait at the sidetrack or car-shed nearest to the theater or park. The Brooklyn Heights R. R. has now about 150 miles of line, extending through the principal streets of the city and through several suburban districts, but arrangements for through service have been made with some of the other companies, so that practically any part of the city can be reached, as well as Coney Island, Jamaica Bay and other pleasure resorts. In view of the growth of outlying suburban residence districts, which growth is largely due to the electric railway facilities, it is not improbable that the introduction of parlor cars for pleasure service may lead to their introduction for a regular service to the city in the morning and to the suburbs in the evening. The crowded condition of the ordinary cars at these times is specially inconvenient for the long-distance passengers, whose journeys may occupy from half an hour to an hour, and many of these passengers would be willing to pay a somewhat higher fare to ensure a seat in a comfortable and well-lighted car. The possibilities of such an arrangement have been taken under consideration by the officers of the railway company, but no steps in this direction will be taken just yet. The service will resemble somewhat that of parlor cars or steam railways. There is a porter in charge of each car, and refreshments may be provided by the party hiring the car, or the company will make arrangements to furnish refreshments, table equipment, waiters, etc. Mail and freight service have already been introduced extensively on city and suburban electric railways, and with the introduc-

STELLA CREVASSE ON THE MISSISSIPPI RIVER IN 1891.
View Showing Revetment of Ends by Sacks.

A VIEW OF THE CURRENT THROUGH THE STELLA CREVASSE.

A CAVING BANK ON THE MISSISSIPPI RIVER.

BANK PROTECTION WORK IN PROGRESS BY THE MISSISSIPPI RIVER COMMISSION.
River Below "Medium" Stage.

THE CONTROL OF THE MISSISSIPPI RIVER.

Accompanying Paper by Wm. Starling, M. Am. Soc. C. E.

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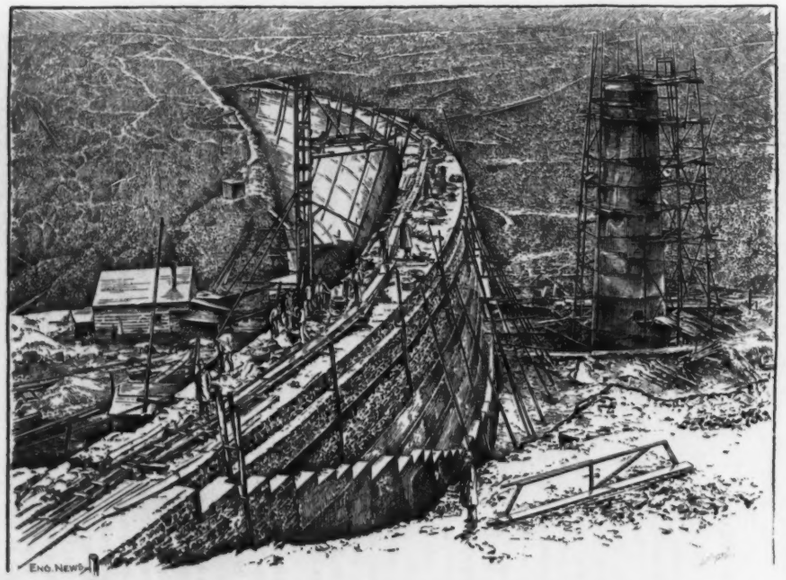


Fig. 3.—VIEW OF DAM AND INTAKE TOWER UNDER CONSTRUCTION.

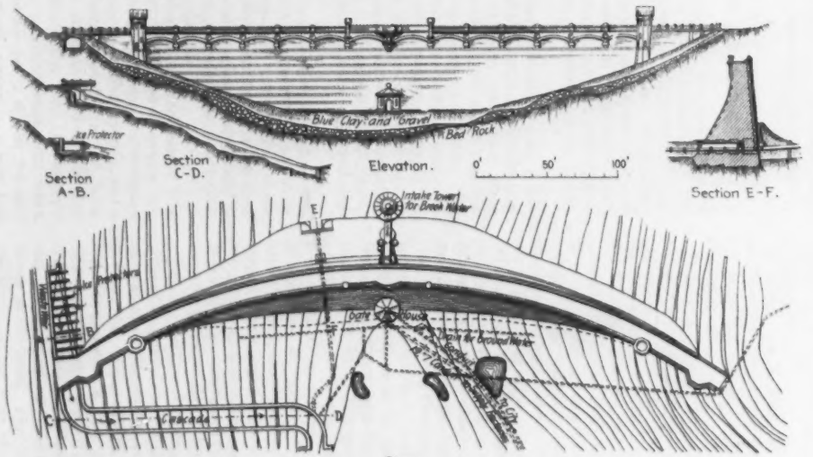
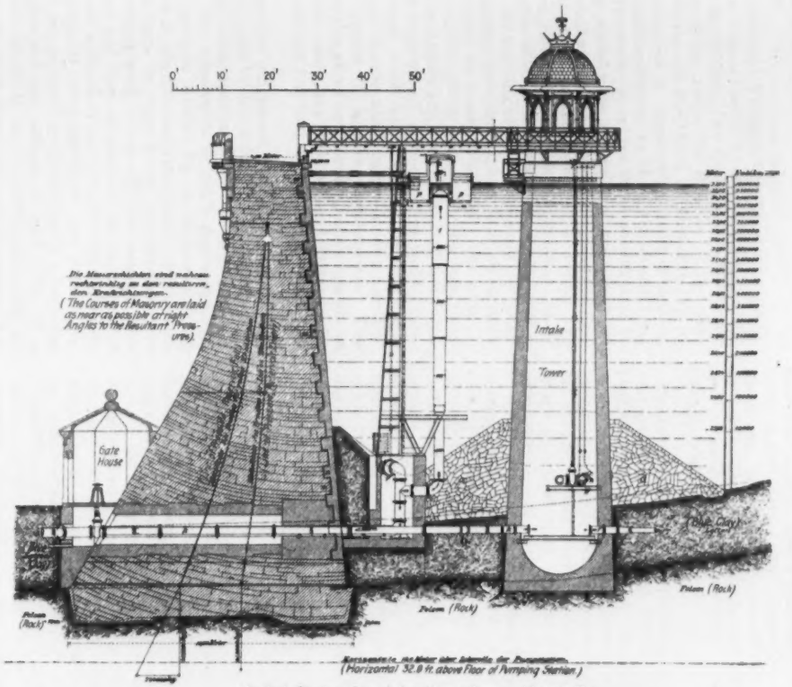
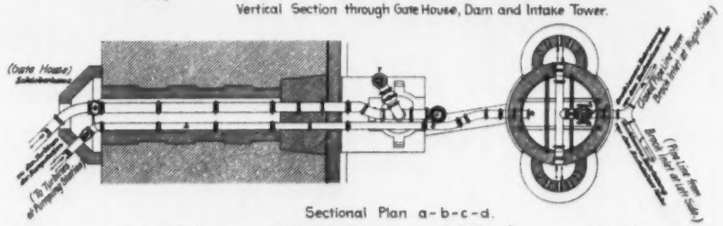


Fig. 1.—PLAN AND ELEVATION.



Vertical Section through Gate House, Dam and Intake Tower.


(Gate House)
(To Turbines of Pumping Station)
(Pipe Line from Brook Water at Upper Gate)
(Pipe Line from Reservoir or Lower Gate)

Sectional Plan a-b-c-d.

m Layer of Asphalt and Cement.
n Brick Lining Wall.
p. Float.
t Telescopic Pipe.
v Emergency Inlet.
f Conduit of Brook Water for City.
g Outlet Valve for Brook Water.
h Inlet Valve for Brook and Reservoir Water.
k. Pipe Line to Pumping Station.

Fig. 2.—CROSS SECTION AND SECTIONAL PLAN.

CURVED DAM FOR THE WATER WORKS OF REMSCHEID, GERMANY.

Prof. O. Intze, Chief Engineer.

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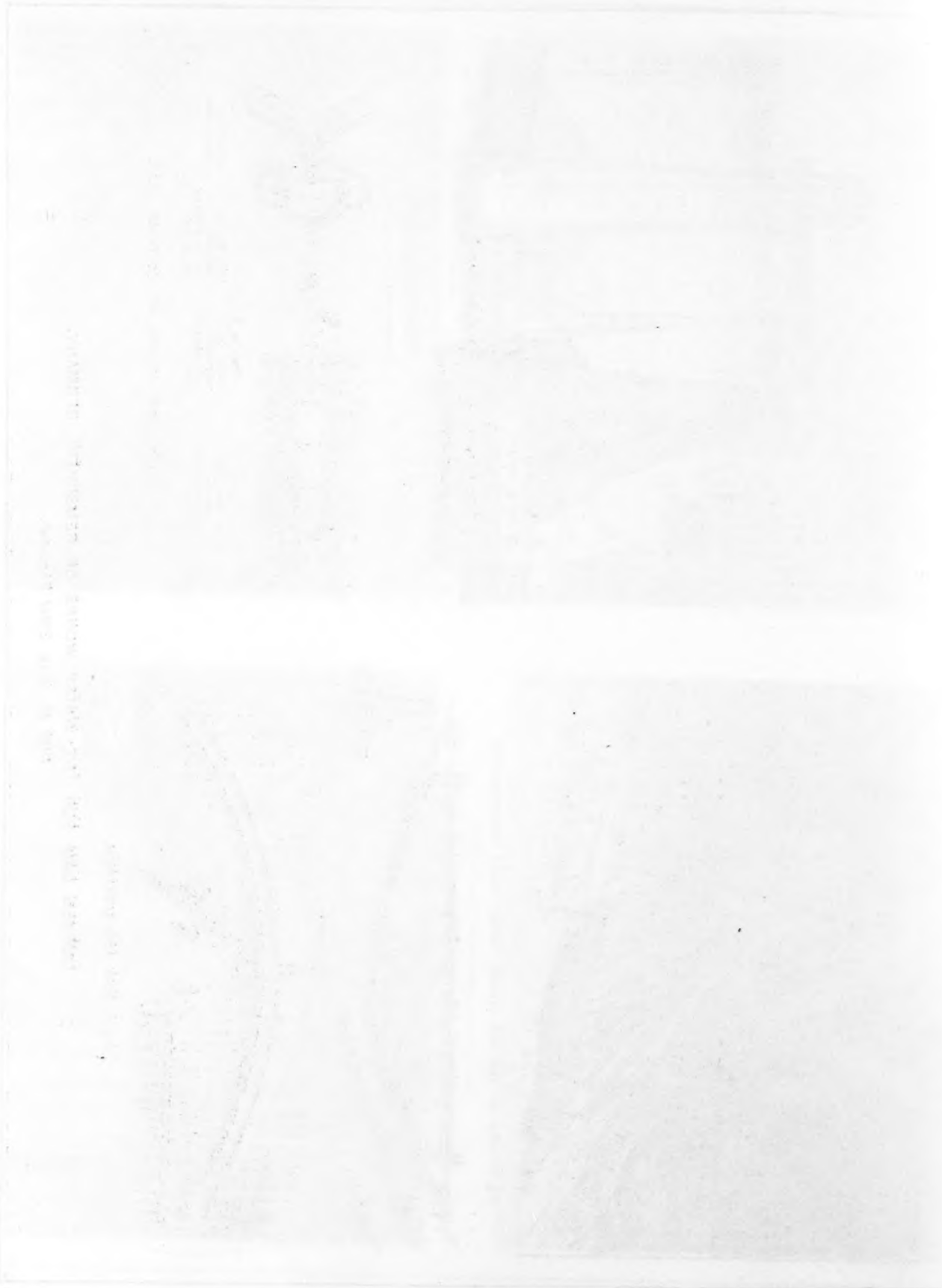

tion of parlor cars for special or regular service the operation of large systems of electric railways will approximate more nearly to that of steam railways.

A bill creating a National Commission on Highways has been introduced into Congress providing that one Senator, two Congressmen, the Chief Engineer of the Army, the Director of the Geological Survey and the Chief of Road Inquiry, in the Department of Agriculture, shall constitute this commission during the life of the present Congress. The work cut out for this commission is to generally consider the promotion of good roads by Government action, the scientific locating and construction of roads on the Government domain, the testing of road materials and the pointing out of the location of such materials by the Geological Survey, the building of model roads and the favoring of instruction in road construction in all institutions under Government control. The commission would also confer with the Interstate Commerce Commission and with railway officials, with the view of obtaining reduced rates on the transportation of road materials, and by conference with State Boards assist in awakening a general public interest in highway construction. The appropriation asked for is the very moderate one of $10,100.95, being the unexpended balance of the appropriations for road inquiry in the last two years.

The general purpose of this bill is a good one; but there must be strong doubt as to the efficiency of a road commission appointed in the manner proposed. The commission is not a permanent one, which can gain wisdom by experience, and the members of the proposed commission, without exception, have on their hands an abundance of more pressing work, which will first demand their attention and best efforts, and the promotion of good roads will simply have what is left. The subject matter of investigation is now a most important one, demanding special expert knowledge, experience and any amount of hard work. It is important enough to have a commission solely devoted to this work, if the National Government is to take it up at all.

But why should a national commission assume a work which can be better done by the separate States? A scheme of national education on the general importance of good roads and the compilation of national statistics on this head are well enough, and the present bureau of road inquiry is doing some good work in this direction without the detailed aid of Senators and Congressmen. But when roads are actually to be improved the money must come from separate communities and States, and local education, by the actual construction of model roads and by other means, is the most effective method of securing good results. That this work can be done by State commissions, the excellent progress made by the Road Commission of Massachusetts is a sufficient proof. The one thing needed in such a commission is just what this bill does not provide for, and that is the undivided efforts of experienced and intelligent men, properly backed by legislative action by the State itself.

What is wanted is local rather than national education, for until the people of any community or State begin to appreciate the value of good roads and the waste of bad ones no practical progress can be made. In this connection the plan followed by the Road Commissioners of Massachusetts is an excellent one, and it can be inaugurated in any State. Object lessons, in the form of scattered sections of scientifically constructed roads, built by local contractors and out of the best available local material, but under expert direction, tell the farmers at once how such roads should be built and what they cost. The good road is there to compare with the bad by actual use, and the construction of these isolated sections of highway educates a class of good-road builders, who can extend the system in any section as its merits become more apparent. The test of this method lies in the fact that in Massachusetts the people are beginning to loudly demand an extension of the improvement, because they see its advantages; and when this feeling prevails, the final solution of the problem is only a question of time. Our chief objection to the national commission proposed is that it is not so constituted as to be able to do the work demanded of it, and that almost exactly the same work is being better done in Massachusetts, and can be done in any State which will take the trouble to appoint proper men upon its road commissions, and support these commissions by proper legislation. A national commission might assist in awakening separate States to the importance of such a movement, but the actual work must be done by State authorities.

The very valuable and interesting paper on the "Levees of the Mississippi River," by Mr. Wm. Starling, in this issue, will, we are sure, be appreciated by our readers for its literary merit as well as the technical information presented. It is seldom, indeed, that a contribution reaches us which is so nearly a model of what we believe an engineering paper should be in respect to literary form as this of Mr. Starling's, and we especially commend its perusal to young engineers who wish to study how to put their contributions to engineering literature into the best possible shape.

Mr. Starling has condensed more information concerning the Mississippi levees into fewer words than has ever been done in any paper on this topic that has ever come to our notice, and he has at the same time made a paper so explicit and well worded that it is as easy reading and entertaining as a novel.

The final test of the success of a technical paper as of a technical work is whether it accomplishes the object for which it is intended. The object of an engineering paper is to inform the reader, and to effect this his interest must be held, by presenting the facts in so clear and concise a form that his mind will grasp them without becoming fatigued. In too many professional papers this simple rule is lost sight of altogether; the writer sets down his facts in the first words that come to him, with no thought of logical arrangement or clearness. Mr. Starling's paper is in delightful contrast to this class of writing. After a perusal of his paper and an examination of the engravings accompanying it, reproduced from some excellent photographs by Coovert, of Greenville, Miss., one feels as if he had examined the works on the ground. The only criticism which we imagine any of our readers may make of the paper is that it does not tell enough; but this is no fault of Mr. Starling, it is chargeable only to the editor's inexorable restrictions respecting space.

CALCIUM CARBIDE AND ACETYLENE.

There are two things which the man who is asked to invest money in a new invention will invariably wish to know: First, is it valuable? Second, is it new? By "valuable," we mean, is it an invention which can be practically made and sold at profit? By new, we mean, is it so novel that valid patents can be secured upon it, with claims sufficiently broad to deter competitors from entering the business?

For a year or more the newspaper and trade press have been publishing articles concerning calcium carbide and acetylene, until they have awakened a popular interest in it which reminds one of the aluminum craze of a few years ago. We gather from the numerous reports which reach us that the promoters of the acetylene business are exploiting their product by the sale of State and city rights, at large figures, to parties who organize local companies to own and control these rights, capitalizing them at enormous sums and distributing the stock broadcast.

Now, there is, of course, nothing illegal in this method of exploiting a new invention. Doubtless it yields a larger and surer return to the owners of the patents than any other plan; but at the same time it is a plan which invariably arouses suspicion as to the soundness and actual merit of any new enterprise whose managers follow it.

There is something else to be said about this method of promotion, and that is that whenever it is chosen, the actual merits and demerits of the scheme exploited become no longer a private matter, but a matter of general public importance. If John Smith is trying to sell his patent on a new pipe wrench to a tool manufacturer, that is a private matter between the parties concerned; but when thousands of persons in all parts of the country are invited to invest their money in a new and experimental industry, it behooves those responsible for this invitation to make a clear and frank showing of all they have and all they claim to the public whose savings they ask for; and it is a matter of public concern that they should do this, and that the showing should be a satisfactory one. There are many reasons why the merits and demerits of such an enterprise are a matter of public concern. We need not enumerate them now, further than to point out that the failure of any such scheme to fulfil its promises to those who put their funds in it makes the investing public wary of all new enterprises, and makes more difficult the attempt of an honest inventor or manufacturer to secure capital.

We publish in this issue two papers on acetylene, both written by experts, who have been engaged in the study of the new product, its method of manufacture, etc. Both of these gentlemen agree that acetylene is likely to come into commercial use; but one is much more sanguine than the other concerning its commercial prospects.

Dr. Birchmore, it will be noticed, declares his conviction, based, we believe, on a careful and thorough study of the patent records and of scientific literature, that the patents on the production of carbide and acetylene, which are being exploited in such a wholesale manner, are invalid and cannot be sustained in the courts. Mr. McMynn makes no reference whatever to the validity or the reverse of these patents, and it must be frankly said that his paper gives really very little satisfactory information concerning the carbide manufacture, which we believe is really all that he has personally investigated.

It is common knowledge that very sweeping claims have been made for the new illuminant. It has been asserted that the carbide could be produced as a by-product in any electric lighting station, thus giving the machinery something to do in hours of light load. The cost of its manufacture has been put as low as $5 per ton, and by comparing the candle-power hours in the gas which a ton of carbide will produce with the candle-power hours in 1,000 cu. ft. of city gas at retail prices, an enormous value has been computed for the new product. Of course, only the credulous will put confidence in a method of computing values in which the absurdity is committed of taking the retail selling price of the article with which the new product is to compete as the standard of values.

It seems worth while to briefly review in these columns the several steps in the new process and see what are its real commercial possibilities or probabilities.

Taking up first the production of the carbide, the process, briefly stated, is heating a mixture of carbon and lime in an electric furnace. This produces a direct combination of calcium and carbon (CaC_2). In effecting this chemical change a large amount of heat is absorbed. How much is a question on which authorities appear to differ. A writer in the "Western Electrician" of Nov. 16 last, stated that 2,559 heat units (lb. Centrigrade) are absorbed by each pound of carbide produced. On that basis the theoretical maximum production per horse-power hour would be 0.555 lbs. Dr. Birchmore, in his paper in this issue, states the carbide production per horse-power hour at 1.374 lbs., based on the theoretical amount of heat absorbed. The promoters of the industry claim to have actually made in their works at Spray, 15 lbs. per 24 hours per horse-power or 0,625 lbs. per horse-power hour, and to expect to make 20 lbs. per 24 hours or about 0.83 lbs. per horse-power hour in their new plant at Niagara Falls. We do not know the authority on which either of the above theoretical statements are based, and concerning the alleged records in the plant at Spray, we understand that the primitive machinery in use there would make a reliable measure of the power absorbed in the production rather difficult.

The writer in the "Western Electrician" above referred to, Mr. C. R. Harding, also deducts the loss of heat due to the fact that the carbide is formed at a very high temperature, and manifestly all the heat contained in the mass after the chemical charges occur is a loss. This appears to be correct; and on this basis he computes the probable practical efficiency in carbide production at ¼ lb. per horse-power hour. Assuming 300 working days of 24 hours in the year the annual production, according to these figures, would be 1,800 lbs. per horse-power-annum.

On the other hand, if we accept the statement that 20 lbs. per day per horse power of electric energy can be produced, we have an annual production per horse-hower of 6,000 lbs., or 3 tons. There are a number of water-power plants where electrical energy can be furnished at $18 to $30 per horse-power per annum, and in some cases even less figures might be obtained It thus appears that the investor in acetylene stock will do well to ascertain, first of all, the actual theoretical heat absorption in the production of calcium carbide. It is not a matter of authoritative record; it should be determined experimentally by competent and disinterested chemists, for the commercial practicability of the carbide industry hinges upon it in the first place.

But while we may be certain that cheap power and an efficiency of not less than one ton per annum per horse-power are doubtless essential to the commercial success of carbide manufacture, these are by no means the only conditions. How much heat is lost in the electric furnace? Is it 80% or 50% or 20% of the total received? Only experiment can definitely settle this question; but we are inclined to believe that a loss of 50% will be about the lowest attainable. The temperature of the furnace is enormous, 5,000°C., it is said, and every one knows that the difficulty of preventing the transfer and dissemination of heat increases enormously with increase of temperature.

But besides the electric power which generates the heat for the electric furnace, there will be found a large number of other expenses when the manufacture is undertaken on a commercial scale. We may briefly note some of them:

Raw Materials and their Preparation.—Lime and coal are reasonably cheap, provided any ordinary commercial grades can be used; but it would not be at all surprising if it were found that a considerable degree of purity were required in each to avoid undesirable combinations in the furnace. Each of these materials must be crushed and ground to powder, and the two must be intimately mixed. This means, of course, a certain amount of expense.

Other Expenses of Carbide Manufacture.—We can do little more than enumerate a list of those that occur to us as, follows: Carbons, furnace repairs, labor, superintendence, interest on cost of plant, depreciation, taxes, insurance (provided it could be secured), preparation of product for market, packing, storing, shipping, etc.

We sincerely doubt whether the people who are investigating in acetylene stocks, or those who are talking so glibly about the manufacture of carbide by electric-light companies, really appreciate just what sort of stuff calcium carbide is, and especially the fact that it not only gives off acetylene when moistened, but gives it off continually by taking up moisture from the air. Consider what this means with respect to its manufacture, handling and transportation. As soon as it is made it must be packed in air-tight receptacles of some sort, and kept in them until it reaches the point of final use. Like every other combustible gas, acetylene is violently explosive when mixed with air; in fact we are informed that its air mixtures are even more explosive than ordinary hydro-carbon gases. It is manifest that the handling, packing, transportation and use of such a substance must be attended with extreme care at every step; and even with such care a certain percentage of accidents must be expected. The investor in carbide securities will do well to inquire what methods it is proposed to use for packing, storing and shipping the carbide, and what the expense is likely to be. We apprehend that the risk which will apparently be inseparable from carbide manufacture, will be such that electric-lighting companies will not venture to thus put in jeopardy their power stations and the expensive machinery therein.

The Use of Acetylene—The brilliancy of the new gas as an illuminant is so great that its exhibition is a most impressive spectacle, and has probably been the most influential factor in attracting investors to the new industry. It does not follow from its brilliancy, however, that the new light is certain to be popular. The public has long been accustomed to the use of yellow light for artificial illumination, and such brilliant white lights as the electric arc lamp and the gas burner are rather slow to find popular favor. They are said to give a green and ghastly hue to objects. Of course this consideration would at most retard the popularity of the new light in certain fields. In outdoor lighting, for example, it would be of no importance.

Doubtless the most important question as to the use of acetylene (provided it is found that its production is commercially practicable) is, how shall it be burned? It was at first proposed to sell the carbide, and let each householder make his own gas from it; but the absurdity of putting such an inherently dangerous process as gas generation in the care of ordinary household servants was so apparent that this scheme, we believe, has been practically abandoned. If not, it had better be. At present the proposition which meets most favor is to distribute the gas liquified by pressure, in steel cylinders, and let every householder connect such a cylinder to his house piping. What is likely to happen with more or less frequency with such a system was illustrated a few days ago at New Haven, Conn., when a cylinder of acetylene "let go," killing three persons. We do not know the pressure at which acetylene liquifies, but it is probably pretty high. We understand also that the storage of acetylene in closed cylinders is peculiarly dangerous on account of the fact that impurities are liable to be present in the gas which will combine with it under certain circumstances with the evolution of a great deal of heat.

To what extent these dangers can be modified or guarded against is a question which only extended experience can settle. It may be that it will be possible to so systematize and safeguard the manufacture and use of acetylene that it may be available for the lighting of cars or boats, or for isolated country houses. But that such a system could form a dangerous competitor of gas or electric light for illumination of city houses seems very unlikely. The average householder wants his light furnished with the least trouble and attention possible. He wants no bother in replenishing his supply at periodic intervals, and, above all, no complicated apparatus about his premises which may become dangerous if monkeyed with by an ignorant servant.

Looking at the matter on general principles merely, it has seemed to us that the best prospects for the commercial success of acetylene were in its adoption as an enricher for ordinary city gas. Dr. Birchmore claims, however, in his paper in this issue, that the conditions of combustion in ordinary water-gas, such as is now in general use, are such that acetylene gives practically no benefits when mixed with it. If this is correct and acetylene must be used pure if at all, its chances of commercial success would seem to us much better if distributed through the present street mains from central stations, or even through new and independent mains, than if reliance is placed on any scheme of distribution in a liquid form in cylinders under high pressure.

Concerning the patents on the manufacture of the carbide, etc., which are being so actively exploited, we have already stated that their soundness has been publicly questioned. Inasmuch as the value of the "rights" which are being disposed of at such large figures, according to newspaper reports, depends entirely upon the validity and breadth of these patents, those proposing to invest in acetylene stocks will do well to carefully investigate this matter. The brilliancy of acetylene as an illuminant will avail nothing to the buyers of these "rights" unless the monopoly which they purport to create can be legally maintained.

LETTERS TO THE EDITOR.

Simpler Formulas for the Flow of Water in Pipes.

Sir: In common, I presume, with most other hydraulic engineers, I have taken a great interest in the results shown by the 48-inch pipe of the East Jersey Water Co. I have long been convinced of the danger of placing confidence in calculated results based on formulas in which minute account is taken of varying conditions of interior surface, relative velocity, etc. Not that these conditions—particularly those of interior surface—are not controlling factors, but simply because it is practically impossible to determine these conditions for any given system of pipes, and still more impossible to predict how long these conditions may continue to exist without undergoing modifications and changes due to time and service. We know as a fact that the delivery of a pipe line must go on diminishing with age, owing to the formation of a greater or less degree of incrustation, not to speak of the probability of leakage gradually being developed. It has appeared to me, therefore, that costly disappointments would be avoided by using simpler formulas, containing a more liberal allowance for unknown and unknowable factors.

In making the calculations some years ago for my little work on hydraulics, I was struck with the fact that the adoption of a reasonable mean co-efficient for rough pipes, or those which had been some years in service, led to the following formulas, which may be said to represent the absolute maximum of simplicity, for the co-efficiency is reduced to unity.

$$Q = \sqrt{D^5 + H} \quad \ldots\ldots(1)$$

$$D = \sqrt[5]{\frac{Q^2}{H}} \quad \ldots\ldots(2)$$

Also, approximately:

$$V = \sqrt{D + H + 1.6} \quad \ldots\ldots(3)$$

In these equations:
Q=cubic feet per second.
D=diameter of pipe in feet.
H=fall per 1,000.
V=feet per second.

When Mr. Rafter's paper upon the detected inaccuracies of the Rochester experiments was read (Jan., 1892), before the American Society Civil Engineers, I applied, in my discussion of the same, the above formula (1) to the 36 and 24-in. compound system of pipes mentioned. The delivery of these pipes, according to the calculations which had been made, should have been 14.39 cu. ft. per second. The actual measured discharge was only 10.43—that is, the actual discharge was on'y about 72 % of the calculated. Applying formula (1), as above stated, to the 36-in. pipe, the fall per 1,000 being 0.45, the discharge was found to be 10.46 cu. ft. per second, or almost exactly the true one. Applied to the 24-in. pipes, in which the grades were 3.83 and 3.58 per 1,000, the average discharge per (1) was found to be 10.89 cu. ft. per second; a very close approximation to the truth, and forming a striking contrast to the totally inaccurate results obtained by a presumably more intricate formula

Now, turning to the New Jersey pipe line, the calculated delivery was 50,000,000 gallons per 24 hours, or 77 37 cu. ft. per second. The actual discharge through a new clean pipe was 34,000,000 gallons—that is, the actual discharge was 70 % of the calculated, practically the same as for the Rochester line, thus showing that the same course of reasoning lead to about the same degree of inaccuracy in the two cases.

Now, let us apply formula (1) to the East Jersey pipe line Mr. Hering, in his communication in your last issue, which I have just read, and which prompts the present letter, gives the fall per 1,000, or H as 2. We have then

$$Q = \sqrt{4^5 + 2} = 45.25 \text{ cu. ft. per second.}$$

This is about 84 % of the actual discharge from the new clean pipe, and may be assumed to represent the probable delivery in a few years, when the pipe shall have become more or less incrusted.

Again, suppose we had wished to determine the proper diameter for a pipe to deliver 50,000,000 gallons per 24 hours, or 77.40 cu. ft. per second. Using (2) we would have:

$$D = \sqrt[5]{\frac{77.4^2}{2}} = 5 \text{ ft.}$$

Now the point which I wish to make is just this: If, in designing the East Jersey pipe line the many probable—nay, certain—defects inherent to a long line of pipe of large diameter had been taken into consideration, all ultra refinement of calculation based upon assumed perfection of workmanship discarded and a simpler formula used, the result would have been a triumphant success instead of mortifying failure. And the same may be said, under different circumstances, of the Rochester line.

I think I cannot better terminate this communication than by quoting the following paragraph from the discussion of Mr. Rafter's paper already referred to:

"To me one of the most important features of these experiments is that they emphasize the fact that, in view of the many retarding influences at work inside of an ordinary pipe line, particularly after the lapse of years, during which the consumption is increasing, it is unwise to put faith in hair-splitting formulas, which raise false hopes as to the capacity of the pipes."

Very faithfully yours,
Yonkers, N. Y., Jan. 25, 1896. E. Sherman Gould.

(A member of the editorial staff of this journal was in Minneapolis last week, and while calling on Mr. J. T. Fanning, M. Am. Soc. C. E., asked him for his views regarding the deficient carrying capacity of the 48-in. steel pipe line under discussion, referring especially to Mr. Herschel's letter to the Board of Directors of the East Jersey Water Co., published in our issue of Dec. 19, 1895, and the news note in our issue of Jan. 16. The result of the interview is given below.—Ed.)

Mr. Fanning remarked that the deficiency of capacity of the 48-in. main, which is delivering only 35,000,000 instead of 50,000,000 gallons of water daily, as stated

by Mr. Herschel, was certainly a very serious matter, and remarked also that Mr. Herschel's statement, that all workers and writers in this line of engineering had been deceived as to the carrying capacity of riveted steel water pipes, was a severe arraignment of those engineers working largely in this line. Mr. Herschel appeared to cite only the Rochester, N. Y., compound conduit of 36 and 24-in. pipe laid in 1870 to justify his broad assertion.

Mr. Fanning stated that he had gone over the Rochester pipe line near the close of the year 1889, in company with the Chief and Assistant Engineers of the Water Board and the patrolmen of the line. Data was then being gathered for a report on an additional water supply for the city of Rochester, which report was made in the following February by Mr. A. Fteley, M. Am. Soc. C. E., and himself.

The Rochester pipe was then in use to its full capacity, and the draught by the city was so great that the storage reservoir, known as Rush reservoir, was drawn down very low. The patrolmen stated that the pipe line was in good condition and no leaks of any importance were discovered, but several locations were pointed out where there had been great difficulty in placing the pipe because of quicksand foundations. The necessity of constant use of the pipe to maintain the draught of water by the city precluded the possibility of making a weir measurement of the flow of water in the pipe, and Rush reservoir was covered with ice.

Referring to his original notes, Mr. Fanning remarked that the city had acquired the right to draw 9,000,000 gallons of water from Hemlock lake, and a measurement of the flow through this pipe when first completed had been reported as at a rate of nearly 9⅓ millions gallons per 24 hours. The profile of the line showed that the first section from the lake was 50,776 ft. in length of 36-in. riveted pipe, with a fall to the end of 28 ft. from normal low water in the lake, giving a hydraulic gradient sloping 0.583 ft. per 1,000 ft. The second section was shown as 51,495 ft. of 24-in. pipe, falling approximately 118 ft. to the surface of full Rush reservoir, giving a hydraulic gradient sloping 2.291 ft. per 1,000 ft. This 24-in. pipe was in part riveted and in part cast-iron. The total head from lake to full reservoir was stated to be approximately 146 ft.

Mr. Fanning stated that he had checked the probable capacity of this pipe by his diagram showing the friction of flow in smooth cast-iron pipes, such as are ordinarily in use in public water supplies, and found that in such pipes a total head of 165 ft. was required to deliver 9,000,000 gallons, and checking again by coefficients deduced from experiments with new asphaltum-coated riveted pipes, the computed head to deliver 9,000,000 gallons was 148 ft.

The diagram indicated a flow at a rate of 8,400,000 gallons in equivalent cast-iron pipes and the computation for new riveted pipe indicated a flow of 8,900,000 gallons daily, on the assumption of 146 ft. total head.

The lake was at that time above its low water level and the reservoir much below its full level, giving more than its normal head. Messrs. Fanning and Fteley therefore expressed the view that the conduit was then delivering approximately 9,000,000 gallons of water daily, if the pipes were free from leakage and the interiors smooth, as described to them.

More recently (in 1890) Mr George W. Rafter, M. Am. Soc. C. E., who was Assistant Engineer of the Water Board, and who had, in 1889, accompanied us over the line, made a careful measurement of this old pipe line, and made piezometric observations of its actual hydraulic gradients in the different sections between adjacent air valves. A description of this survey appears in the transactions of the American Society of Civil Engineers for January, 1892.

Mr. Rafter states that the total fall between the lake and reservoir is 143.8 ft., instead of 146 ft., and that the fall in the 36-in. pipe is 21 ft., instead of 28 ft., as shown on the original profile drawing, which shows a reduction of 25 % of the effective head of the 10 miles of 36-in. pipe.

The piezometric test should have shown a substantially uniform gradient in this 36-in. pipe, but the indications were variable and show at a few points a considerable increase of resistance to flow.

In 1894 the Chief Engineer of the Water Board made some gagings at the reservoir of the flow of this compound conduit, and concluded that its delivery rate was somewhat less than 7,000,000 gallons daily, thus confirming the fact that there were local causes for the irregular friction gradient discovered by Mr. Rafter.

The facts in this Rochester case seem to support rather than discredit the computations of those engineers who have had experience in this branch of their profession.

The journey over this old pipe line, in 1889, was for the purpose of discovering the proper line and location of the proposed new conduit of 15,000,000 gallons daily capacity from Hemlock Lake to Rush reservoir. Hemlock Lake lies south of Rochester, and its outflowing stream runs northeasterly about 15 miles toward the city and then westerly to the Genesee River. The old conduit follows the valley of this stream about four miles, and then rises suddenly on to the plateau west of the stream. At about 15 miles from the lake it has dropped down to the outflowing stream. This rise and several other rises appeared to be quite objectionable. A lower line was deemed advisable for the new pipe, and the topography of the country indicated that a better line could be found. A reconnaisance developed a better line with only slightly increased length, and Mr. Rafter was detailed to make an accurate survey of the new line. This survey indicates that if its line had been used for the old pipe, the capacity of the old pipe on this increased gradient would have been 19,000,000 gallons, as compared with between 8,000,000 and 9,000,000 as laid.

Mr. Fanning, being asked to what he would attribute the deficiency in the East Jersey 48-in. pipe line, replied that his information was only such as had been published, together with the description of the line given to the New England Water-Works Association by Mr. Herschel in 1893, and published in its journal for September of that year.

He remembered that Mr. Herschel had stated the hydraulic gradient of the line to be a slope of 2 ft. per 1,000 ft. Referring to his diagram of pipe frictions,* he replied that the diagram indicated a probable flow of 48,000,000 gallons in 24 hours, if the rate of flow was uniform and there were no accumulations of air at the summits. He cited a recent test he had made of a supply main in one of the Lake Michigan cities, where the flow from the lake to the pump well was through a pipe having a summit at its entrance to the pump well, and the accumulation of air in this one summit reduced the effective head of the pipe 6%.

Mr. Fanning remembered that Mr. Herschel had stated to the New England Association that his 48-in pipe had been designed to operate with the pressures due to its hydraulic gradient only, by control of its flow from the Macopin end, and referred to this as a novel feature which, so far as Mr. Herschel knew, was first embodied in this pipe.

When pipes have been so used heretofore, it has been found necessary to provide means to protect them from collapse at the summits, and when there are numerous summits and many steep grades, as shown in the East Jersey profile, the flow is not solid and at a uniform rate, and there are tendencies to vacuums at the summits. In such cases, the conditions are those of a successive series of pipes from summit to summit, and with varying hydraulic gradients, and their capacities are materially reduced thereby. In such cases, the formula based on experiments with solidly filled pipes with uniform velocities of flow would not be applicable.

The statement that the observed rate of flow in the East Jersey pipe is as much as 35,000,000 gallons daily, instead of 50,000,000 gallons, as Mr. Herschel anticipated, seems, under the circumstances, to again support rather than discredit the computations of engineers familiar with pipe constructions.

The published profile of this East Jersey pipe line indicates that the blunder at Rochester in 1876 served no useful purpose here, for there a very important pipe had been reduced 50 % in capacity by running it over hills when it could have followed the valley, as the new Rochester pipe now does. The East Jersey line, as shown on the published map, seems to nearly parallel the valley while passing over high hills, and eventually to cross the valley as did the Rochester line.

* Illustrating his table of coefficients of frictions in "A Treatise on Water Supply Engineering," Van Nostrand, New York, 1877.

The Collision in the St. Louis Tunnel Caused by a Sleepy Signalman.

Sir: The editorial comment in your issue of Jan. 16, on the recent accident in the St. Louis tunnel, is based upon a misunderstanding of the facts, and I must beg leave to set you right. The traffic through the tunnel is not controlled by a simple manual block, but by a Sykes electric interlocking apparatus at each end of the tunnel. At either end of each track is an insulated section of about four rail lengths, forming a track circuit. When a train entering the tunnel passes over this insulated section it locks the signals behind it, not only locking the levers but closing valves in the pressure pipes, so that even if the levers could, by any disarrangement of the locks, be thrown, the signals would not respond. The normal position of all signals is locked to danger. The operator at the entering end cannot lower his signals until he is unlocked by the operator at the leaving end. On the night of the accident there was no failure of the Sykes interlocking. When the Wabash train approached "X" office (the tower at the west end of the tunnel) the operator called Washington Ave. to unlock his signals. The tunnel being clear, the Washington Ave. operator unlocked the levers at "X" office, thus allowing that operator to clear his signals for the approaching train. When the Wabash train passed over the track circuit at the west end it locked the signals behind it. Before reaching the track circuit at the east end of the outbound track the train was stopped by some defect in the air brake. It was thus stalled between the two track circuits. The operator at "X" office, having had no report of the Wabash train leaving the tunnel, asked the Washington Ave. operator, when the Vandalia train was due, if the Wabash train had passed him. The operator wrongly replied in the affirmative, as you stated, even giving the time when the train passed his office. The operator of "X" office then called for signals for the Vandalia train, and the Washington Ave. operator unlocked him, thus allowing the signals to be cleared for the Vandalia train.

A continuous track circuit was installed through the tunnel some ten years or more ago, but failed completely after a short time and was abandoned. For the past nine years, to my personal knowledge, the tunnel has been operated under the Sykes system with remarkable freedom from failures or accidents. We are now considering the feasibility of installing the tunnel with electric signals, but the problem is one of peculiar difficulties, which can only be appreciated by those who are familiar with the requirements of the traffic and the physical conditions of the tunnel.

No mechanical or electrical block system can dispense with human intelligence. In this case the operator was, as you say, "careful, temperate and trustworthy." Moreover, he was not overworked, as the operators work three shifts of eight hours each. Yours respectfully,

N. W. Eayrs,
Supt. of Structure and Interlocking; Terminal Railroad Association.

St. Louis, Mo., Jan. 20, 1896.

(The local authorities must, of course, be assumed to be good judges of what is practicable or impracticable under local conditions, but we may again call attention to the long and successful use of the track circuit system for the block signaling of the busy four-track Harlem tunnel, which forms part of the approach of the Grand Central Station, in New York city. A track circuit would have prevented the unlocking of the signals in the rear of the stalled train. We are glad to know that there has been such freedom from accidents, and fully realize that human intelligence cannot safely be dispensed with. Undoubtedly the best and safest system is that which effects the interlocking of mechanism and human intelligence.—Ed.)

Effect of Grades on Hauling Capacity of Locomotives.

Sir: If you know of any published results of actual physical tests showing the hauling capacity of locomotives on grades of different percentages of steepness, I would be greatly obliged if you will refer me to such publication. What I wish to ascertain is, how much greater tonnage will a locomotive haul up a 1% grade than up a grade of 2 or 3 %. I want to know the result of any reliable actual physical tests, if any have been made. Yours truly, W. B Bradley,

Gen. Freight Agent; Marietta & North Georgia Ry.
Knoxville, Tenn., Jan. 21, 1896.

(We do not know of any series of tests on this matter, but from a long and detailed table in Wellington's "Economic Theory of Railway Location," we take the following figures of maximum working loads (behind the tender) in regular service. The adhesion is taken as ¼; rolling friction at 8 lbs., and the weights are in tons of 2,000 lbs.

	—Weight, tons— Eng. & ten.	on drs.	Cyls.	Train loads on grades of— 1%	2%	3%	4%
Eight-wheel...	58	24	17x24 ins.	371	192	118	78
Mogul.....	64	32	17x24	577	269	171	118
Ten-wheel.....	67	36	19x24	576	308	198	138
Consolidation.	80	48	20x24	777	420	273	193

Notes and Queries.

J. H. D.—Asks for information concerning horizontal band saws for cutting heavy timber, and of saw mills in which such horizontal saws are used.—A horizontal band saw for cutting Java teak was built a few months ago by A. Ransome & Co., of London, under the Landis patents. The saw is 38 ft. long, 5 ins. wide, running over 5-ft pulleys and traveling at the rate of 7,000 ft. per minute. Can any of our readers supply information as to the use of such machines in this country?

PARLOR CARS FOR THE BROOKLYN HEIGHTS R. R.

The latest innovation for extending the facilities afforded by electric street and suburban railways is the introduction of parlor cars for the use of theater or picnic parties, etc., and we illustrate this week one of two handsome parlor cars recently built by the Barney & Smith Car Co., of Dayton, O., for the Brooklyn Heights R. R., of Brooklyn, N. Y., which has already put mail cars in service, as noted in our issue of Dec. 19, 1895.

The cars are framed with the builders' special iron construction, and have extended platforms supported by T-iron sills. They are each mounted on a pair of the Barney & Smith class E suspension

Dimentions of Parlor Car for Brooklyn Heights R. R.

Length inside	24	ft.	4	ins.
" of each platform	5	"	6	"
" over all	36	"	0	"
Width inside	7	"	1	"
" over main panels	7	"	9	"
" over cove panels	7	"	0	"
Height from floor to main roof	6	"	10	"
" " " to monitor roof	7	"	$10\frac{1}{2}$	"
" " bottom of sill to top of roof	8	"	6	"
" " rail to top of roof	10	"	11	"
Diameter of wheels	2	"	6	"
Truck wheel base	4	"	6	"
Total " "	17	"	$5\frac{1}{2}$	"
Distance c. to c of trucks	12	"	$11\frac{1}{2}$	"
HP. of each motor	20	HP.		
Weight of car body	8,000	lbs.		
" of two trucks (without motors)	7,500	"		
" total (without motors or electrical equipment)	15,500	"		
" total (in running order)	25,000	"		

spring motor trucks, the construction of which is such that the floor of the car is very little higher than in an ordinary four-wheel car. There is a semi-elliptic plate spring over each axle-box, and the spring hangers are connected to an equalizer formed by an inverted semi-elliptic plate spring under the main sill of the truck. There are also spiral springs at the sides of the axle-boxes. The controllers are of the General Electric Co.'s make, and each truck has a 20-HP. Westinghouse motor. One of the trucks is also fitted with the air-pump (operated by an eccentric keyed to one axle) and mechanism for the Standard Air-Brake Co.'s brake,

Interior of Parlor Car; Brooklyn Heights R. R. Barney & Smith Car Co., Builders.

the brake shoes being applied to all the wheels of the car. The interior is heated by eight of the Central Heating Co.'s electric heaters, placed against the sides near the floor. Light is furnished by three chandeliers of three incandescent lights each and a light carried on a bracket in each corner. All these lamps have opal globes and ornamental shades. Electric platform lights and headlights are also provided. Electric push-buttons, to summon the porter or waiter, are placed between the windows. A Crawford fender is fitted to each car.

The interior is finished in mahogany, with oil finish, and the headlining is of cream colored composition, decorated in gold. The floor is covered with a Bigelow-Wilton carpet, and the windows, which are unusually large and of plate glass, have Burgess tapestry spring curtains, with Burrowes automatic fixtures and silk hangings. There are 20 cane chairs upholstered in brown plush, harmonizing with the peacock-blue effect of the carpet and window hangings. The hand straps are carried in bronze rods extending the length of the car, and all the metal fittings are of bright bronze. In each corner is a buffet, with table top and lockers above and below. Four small tables, for refreshments or cards, can be fitted to the sides of the car. There are double doors at each end, the two doors opening simultaneously when one handle is pulled. The platforms are inclosed with ornamental railings and gates, and the hood of the roof is supported by bronze rods and brackets. A box on one platform carries twelve camp stools, which may be used in the car or on the rear platform.

Each car is in charge of a porter, and waiters and refreshments will be furnished as desired. The cars may be hired by individuals or parties and used for long distance rides to the seaside or other pleasure resorts or for trips for theater or skating parties, etc.

The cars are painted dark blue, lettered and decorated in gold, while the trucks are finished in yellow, pricked out with black. The general dimensions of these cars are given in accompanying table.

CURVED MASONRY DAM FOR THE WATER-WORKS OF THE CITY OF REMSCHEID, GERMANY.*

(With inset.)

The curved masonry dam across the Eschbach Valley, forming a reservoir of 35,310,500 cu. ft. capacity, is a particularly interesting feature of the extension of the water-works for the city of Remscheid.

The dam is shown in plan, elevation and section in Figs. 1 and 2, and in a partially completed state by the view, Fig. 3. It is 13 ft. $1\frac{1}{2}$ ins. thick at the crest; 49 ft. $2\frac{1}{2}$ ins. thick at the base, and about 82 ft. high. In order to avoid tensile stresses on the masonry the cross section has been so determined that the lines of resistance for both a filled and an empty reservoir lie within the middle third of the section.

In plan the dam is curved to a radius of 410 ft. This method of construction was adopted in order to leave sufficient freedom for movements due to variations in pressure or in temperature, as it also admitted of making a better and firmer bond at the wings.

The work was commenced in May, 1889, and in November, 1891, water was admitted into the reservoir.

As will be noticed, the courses of masonry are so laid as to be at any place as nearly as possible perpendicular to the varying direction of the resultant of the acting forces. While this method has not been previously used in dam construction, the author, who was the engineer in charge of the work, believes that it contributes to the safety of such structures, especially by obviating horizontal displacements, when the back pressure is admitted. He refers in this connection to the case of the Bouzey dam, which, however, in other respects was notoriously weak. While, therefore, many do not consider it necessary to lay such courses, the author remarks that for the reason stated, and because it offers no great difficulty, he is in favor of this method, and is using it also in two new dams which he is now building at Altna and Milspe.

The stone, a Linneite slate, was quarried in the immediate neighborhood and is hard and of good weather-resisting qualities; its specific gravity is 2.7, and it has a crushing resistance of 28,400 lbs. per sq. in. It was washed by a stream of water and thoroughly cleaned with steel brushes before being used. The masonry, composed of this stone laid in Trass mortar, weighed 4,045 lbs. per cu. yd. In preparing the rock foundation to receive the bottom courses, it was first cleaned by a stream of water under high pressure, and any existing crevices were filled with concrete before the whole was leveled off with this material. Great care was taken to close up any springs that might be encountered. If any such existed after the bottom had been covered with concrete, they were conducted through pipes either away from the masonry or upward, and when in the latter case the pipe had reached a height at which the water did not appear after a long period, the pipes were filled with concrete and the masonry built over them.

The amount of masonry in the dam and its appurtenances is about 617,935 cu. ft; of this the mortar, owing to the irregular sizes of quarry stones, forms about 38 %.

Careful attention was given to the selection of mortar and the method of applying it, and its proportion of 1 lime, $1\frac{1}{2}$ trass powder and 1 Rhines, and was adopted after an extended series of tests. These tests showed that an increase of sand from $\frac{1}{2}$ to 1 gave a much stronger mortar, both as to tensile and crushing resistance, and tests made since then have caused the author to adopt a still greater proportion of sand in his present works, namely $1\frac{1}{2}$. The tests also showed the superiority of such mortar kept under water to that exposed to the action of the air, and for this reason the mortar was constantly kept moist during construction. Comparing the trass mortar used to cement mortar, the point is made that the former is better adapted to dam building from the reason that it sets more slowly and can be left a whole day after it is made without injury. The tests also show it to be superior to cement mortar in point of elasticity. It should be noted that the trass used in this mortar was very finely ground. No settling of any part of the dam was observed during construction and since then no cracks have appeared. For the reason that most dams show leaks during the first years, a layer of cement mortar and asphalt was applied upon the up-stream side of the dam; the asphalt extending down to the bottom and covering it for about 20 ins. On top of the asphalt a brick wall from $1\frac{1}{2}$ to $2\frac{1}{2}$ bricks thick was laid in cement mortar. For this outside covering the author prefers cement mortar, as it is better able to resist the action of exterior forces than trass mortar.

The dam has shown itself to be perfectly water-tight. The effect of rain has, however, caused moist spots to appear on the outer curved face, and in the dams which he is now building the author has inserted drain pipes below and parallel to this surface.

Careful measurements have been taken to ascertain the radial movements of the dam due to variations in pressure and temperature. The former have caused the greatest movement at the center—1 1-16 in.—while at symmetrical points between the center and the wings the observed motion was 9-16 in. The greatest effect due to temperature changes was observed during a very hot and dry summer upon the curved surface, and was $\frac{7}{8}$ in. on one side of the dam against only $\frac{1}{8}$ in. on the other. This unsymmetrical action is explained by the fact that the former was entirely exposed while the latter was largely protected against the influence of the sun. The author believes that if the dam had not been curved these movements would certainly have produced cracks.

The cost of construction of the dam, its overflow and spillway, excluding payments for land, amounted to 383,000 marks, or $91,154.

As the reservoir was to do service not only for the water supply of the city of Remscheid, but was also, according to agreement with the city authorities, to supply motive power to numerous manufacturers in the Eschbach Valley, it was decided to separate the supply for the two purposes, so as to keep the purest water for the city itself. For this purpose two brooks, which flow into the upper end of the reservoir, were dammed up separately and their flow was collected in wells. From these the water is conducted by vitrified pipe lines along the slopes of the valley, with very little grade, to points near the masonry dam; from these points it is conducted by cast iron pipes under considerable head into the collecting tower, which is located about 36 ft. distant from the dam. The purer brook water, therefore, is conducted separately into the immediate vicinity of the dam without coming into contact with the water contained in the reservoir. The quantity of the water taken from these brooks is, of course, subject to fluctuations, as is likewise the amount of the water delivered from the pumping station; therefore, the capacity of the collecting tower would at times prove inadequate. For this reason the self-acting valves (g and h), shown in Fig. 2, were resorted to. Whenever the influx of the brook water exceeds its consumption, this water passes through the outlet valve into the reservoir; when a greater amount of water is pumped than the two brooks supply, the reservoir water flows into the tower. The interior of the gate tower may be drained whenever the water in the reservoir is not too high by closing the gate valve on the inlet and outlet pipe shown, and cutting off the conduits supplying the brook water.

The ordinary outlet of the water in the reservoir is through a telescope pipe, suspended from floats, the mouth of which can be raised or lowered, according to the temperature or the level of the water. At a very low level an emergency inlet, which is operated from the bridge, connecting the crown of the dam and the collecting tower, comes into action.

*Abstracted from a paper by Prof. O. Tutze in the "Journal of the Society of German Engineers," by O. J. Marstrand, M. Am. Soc. C. E.

THE LEVEES OF THE MISSISSIPPI RIVER.

(Concluded from page 71.)

When there is no firm ground on the land side in which to drive stakes, as when there is water standing against the back slope, the ingenuity of the engineer is sometimes pretty severely taxed. Brush, in one form or another, held down by earth, loose or in sacks, is the unfailing resource. Sometimes it is made in the form of mattresses, or rough fascines. In fact, the variety of high-water work is infinite.

Crevasses.

In spite of all precautions, a crevasse will sometimes occur. It is proverbial among levee men that breaks seldom happen where they were expected. There are persons, especially of the old school of "high-water fighters," who take pleasure in believing and proclaiming that the Mississippi and everything relating to it are not governed by the ordinary laws of nature, and that there is no calculating what it may or may not do. The reason that breaks do not often happen in places known to be dangerous is that such places are always carefully watched and the weak points strengthened. When crevasses do occur, it is generally because of some hidden defect which could not be suspected, or some circumstance that could not be foreseen or controlled.

Levees very seldom break from sloughing, for that is easily remedied. They seldom, of late years, break from insufficient cross-section; they never break from sliding or overturning, as they ought to do, by rule. They do not often break from storms, though sometimes they have run very narrow escapes. Crevasses are due mostly to three causes—to being overtopped by the water, to holes through the levees, and to weakness of the foundation.

In former years the most common of all causes of breaks was insufficiency of height. In 1882 the average height of the levees of the Lower Yazoo District was about 7 ft. The head against such levees can never be formidable to the underground; holes in them are easily stopped; the depth on the foreshores was seldom great enough to permit the formation of considerable waves. But even a thin stream of water running over a bank of light or ordinary material will effect its destruction. On the lower coast of Louisiana, where the soil is a stiff black clay, it is said that water may run for twenty-four hours over a levee without material injury. Breaks in this locality usually occur, it is said, through the ravages of boring animals, through neglected rice-flumes or from similar accidents. Even after they occur they enlarge very slowly, and if taken in hand within a reasonable time after their occurrence, they may generally be closed.

A very different condition prevails in the upper parts of the valley. If water be allowed to run over the levee, little gullies soon cut out which develop into great ones; a cascade pours through the cut, which erodes great holes in the back slope; huge blocks of earth fall in from the sides, and the mischief is soon irreparable. Once made the crevasse enlarges with fearful rapidity. When first discovered, it is perhaps 20 or 30 ft. wide; in an hour or two it is 100 ft., next morning it is 300 and the next 500 or 600.

In the famous flood of 1882, the water gradually reached the tops of the levees, and in places rose above the crown. The people turned out in force and raised the embankments, little by little, by a temporary "topping," placed on the original crown—the earth being generally taken from the back slope of the levee itself. Sometimes sacks were used, placed in tiers and perhaps reinforced with fresh earth. Sometimes planks were set on edge and backed with earth. In this way, day by day, the people managed to keep up with the rise; till on the night of the 28th of February a furious storm arose, which swept away the slight "topping," and the water ran broadcast over large parts of the line. Next morning there were thirty or forty breaks. The same tale might be told of Louisiana. Arkansas had no levees worth mentioning.

From the experience of this and previous years, it was inferred that the chief danger to be apprehended was from water actually overtopping the levee, and construction was generally turned in the direction of increased height.

In 1890, some 3 ft. had been added to the heights of 1892, when another great flood came There were numerous breaks as before; but this time they occurred before the water reached the tops of the embankments. In the Lower Yazoo District there were five breaks. So far as was observed, all were caused by weakness of some sort in the underground, beneath the base of the levee. In one instance, an eye witness declared that "the ground rose up" 10 or 15 ft. inside of the foot of the slope, and the levee suddenly collapsed. A case which once came under the observation of the writer is strongly corroborative of this statement. In this instance, a small hole, about an inch in diameter, was observed, some 6 or 8 ft. inside the levee, spouting thick, muddy water, about the consistence of chocolate. A finger was thrust into this hole, to ascertain its direction. On withdrawing it, the hole suddenly enlarged to the size of a man's wrist, then rapidly to the size of one's leg, and presently the whole levee gave away to the distance of 20 or 30 ft.

There has been some difference of opinion among levee engineers as to whether these failures are due merely to the weakness of the loose soil of the foundation or to cavities of some sort existing, unsuspected, beneath the embankment. The question is not easily settled, nor, perhaps, is it essential that it should be, so far as the reality of the danger is concerned, or the nature of the remedies to be applied. These have been discussed already.

Closing Crevasses.

The closing of a crevasse is an operation which ranges, in point of difficulty, from the easy to the impossible. In lower Louisiana, where the levees are comparatively low, the foreshores high, the breaks small and the soil strong, so that the gaps cut out very slowly, the closing of a crevasse is frequently a matter of a day or two's labor. The work is done by the planters themselves, who usually have a stock of material on hand, in readiness for such an emergency. In the upper part of the valley, where the levees are high, the soil light, and the crevasse may enlarge at the rate of several hundred feet in a day, the task of closing it will probably be beyond the means at hand within any reasonable time or within the practicable limits of cost.

There is only one plan of closing breaks which has been practiced with success, and that may be called the Creole plan, because it was, so far as is known, first employed by the planters of French descent of lower Louisiana. It has been in vogue with them for a long time. This plan may be likened to the operation of raising a movable needle-dam.

First, a number of bents are set up, analogous to the trestles of a Poiree dam; then stringers are placed to connect the bents; and lastly, hand-piles are driven in front of the stringers, supported by the latter, in place of the needles. The work is completed by filling in with sacks and earth.

The first thing to be done is to get the material on the ground, or enough to start the work; then a large number of men are set at filling sacks. Usually the most difficult part of the task is to get earth enough. Generally everything in the vicinity is overflowed, so that earth has to be boated from a distance, or else obtained from the adjacent levee. The first is slow, the second dangerous. If the levee was weak enough to break, it will not be improved by robbing it of a part of its substance. Next, the bents are to be driven.

For small levees it may be sufficient to have the bents composed of from three to five hand-driven piles. The workmen begin from both ends of the break, driving bent after bent by standing on the ends of run-plank, projecting beyond the bent previously driven. This process brings the bents about 4 ft. apart. The piles are braced together as fast as driven and the stringers placed in position as rapidly as the bents are set up. The pile-dike thus constructed is floored over with plank, on which are placed piles or plank in quantity enough to close the work, and also a sufficiency of sacks (centals) filled with earth. The closing piles are not driven close together, but only near enough to keep the sacks from passing through. They are driven as nearly as possible simultaneously along the line, as many men, with heavy mauls, being employed as can work to advantage. Thus the final operation of closing the line may occupy less than an hour. The sacks are then thrown in front of the continuous line of piles as rapidly as possible.

In the practice of the writer, several small breaks have been closed in this way. In these cases, however, brush in large quantity was used in addition to the small sacks. As soon as the closing of the line by piling was effected, brush was thrown into the water in front of the dike, and pressed to the bottom by forks. This process was repeated until the brush reached the surface of the water. Sacks were then thrown in front of the brush. The latter was replaced as it sank by fresh material. The office of the brush was, first, to economize earth, which was exceedingly scarce; and, second, to give continuity and bond to the structure, so that the scouring-out or breaking of a pile should not cause a breach in the work.

For breaks in deep water this plan has to be modified. The bents are composed of a greater number of piles—sometimes as many as ten. In general, it is said, the width of the dike should be three times the depth of the water. The piles are generally 4x4-in. scantling. Stringers are placed, not only on the front of the bents, but along each row of piles from the front, thus, with the horizontal braces dividing the dike into cribs about 4 ft. square. The continuous piling is also driven in each row. The whole width of the dike is then floored with sacks of earth, thrown in with as much regularity as possible, so as to give about one tier. This course is followed by another, reaching entirely to the front, but stopping short at the back by the length of two or three sacks, so that there may be a projection of the bottom tier to catch the overfall. This process is continued to completion. The work is then finished by a rough coffer-dam or "mud-box," as it is locally called, made by driving light sheet piling in front of the pile-and-sack dike, and filling in between with strong clay.

The most signal example of success in the use of this method was the closing of the Tessier break in Louisiana in 1892, with a maximum depth of 11 or 12 ft. The above details are mostly taken from an inspection of that work by the writer shortly after its completion.

The piles, in these processes, are all hand-driven. Steam pile-drivers have never been employed with success, though there are some interesting records of experiments with them.

If crevasses cannot be closed their ends may be secured and the gap be thus prevented from enlarging further in a lateral direction. In this, as in most other work, the method to be employed will depend on the surrounding circumstances. If the crevasse happen in front of a small basin, the latter soon fills up, the back-water rapidly rises, and the difference of head between it and the river water is reduced, and with it the current through the crevasse. In such cases, if it be necessary to secure the ends at all, it may be done by stringing loaded sacks on a small rope or wire and thus depositing them with regularity from the foot of the broken slope to the surface of the water, so as to form a complete revetment.

If the fall be considerable and the back country open the current through the crevasse continues to be rapid, and a revetment such as that last mentioned would be speedily undermined. In this case an effective expedient has generally been to build out spur dikes of piles (generally steam-driven), brush and sacks, a short distance from the ends of the break. Thus is checked the most destructive part of the current, namely, that which sweeps along the front of the broken levee, around its end, and again along the back slope, seeking the lower level which prevails there.

It is but seldom that persons are drowned from crevasses. The back-water fills up slowly, and there is usually ample time to save life and even property. The principal loss is in buildings and other improvements, live stock and crops.

The administration of the levee system, under present circumstances, is a curious and anomalous combination of United States and State work. With two independent and concurrent jurisdictions, there is abundant room for conflicts and cross-purposes. Nevertheless, the work has been generally harmonious so far, by the exercise of good sense and forbearance on both sides. Since 1882, when the partnership between the Govern-

ment and the local authorities began. in the Lower Yazoo District, about two-thirds of the work has been done by the State organization (the Levee District) and one-third by the United States. Up to July 1, 1896, the respective amount of earthwork put up by the respective agencies will be in this district (from 1882 to 1896): By the Levee Board. 13,233,614 cu. yds.; by the United States Government, 6,342,277 cu. yds. The average height of the levees in this district is about 12 ft.

WILL THERE BE A "CARBIDE" INDUSTRY?

By Dr. W. H. Birchmore.

The substance which is already known among the interested as "Carbide," and seemingly is to be so called for some time to come, is the unstable compound of lime and carbon obtained by heating quicklime in an atmosphere of vaporous carbon until the quick-lime fuses, vaporizes, and combines. The substances thus formed is known in science by several names: "Calcium Carbide," "Calcium Carburet," "Calcium Acetylide," have all been coined and all are current.

If this unstable carbide is thrown into water or exposed to its vapor, it immediately decomposes forming slacked lime and a gas, of an evil smell, intensely poisonous, called ethine.

This gas is found present in small amount in the ordinary coal gas, and has been known to science as klumene, acetylene and ethine, which last is its proper scientific name. Oil enriched water gas contains no ethine, but a larger percentage of its polymers known as pseud-acetylenes.

This ethine is a very peculiar substance and is produced at temperatures where nearly all other gases are rather inclined to dissociation than to formation. Berthelot devised a beautiful experiment, which has become one of the regular exhibits of the high schools, in order to illustrate this: rendering carbon gaseous by the heat of an electric current in an atmosphere of hydrogen, the two combine and produce a gas quite different from any other known. Its formula is $C_2 H_2$, and the carbon part weighs 12 times as much as the hydrogen part, while in methane, marsh gas, CH_4, the carbon part weighs only 3 times the hydrogen part.

This gas has been prepared in a number of ways, but it was ascertained by Wöhler in 1862 that the probably correct way to reach the best method of production was by the decomposition of the "carburet" of some alkali-metal. Then began a search for carbides.

Sir Humphrey Davy had made the first one of them ever artificially formed by heating plumbago and metallic potassium in 1809. His description is not distinct because he had no true idea of what he had done.

Years passed by, and Edmund Davy repeating the classic experiment, obtained the gas, discussed it, called it klumene. But he did not properly study his carbide. This was in 1836.

1862 came and with it Wöhler's famous experiment by which he made the first carbide by intentional synthesis. His work is recounted in Ann. Chem. u. Pharm., CXXIV., 220. It it improbable that this was the first, but it is the official announcement.

Roscoe and Schorlemmer in their characteristic way summarize his whole article in one sentence (Vol. III., pt. 2, p. 455), "Calcium acetylide CaC_2 is obtained when an alloy of calcium and zinc is strongly heated with charcoal. It is decomposed by water into calcium hydroxide and acetylene." Various men working on Wöhler's suggestion made the carbides of various metals with more or less of success, but of course without obtaining results of any commercial value, of which indeed they probably never dreamed.

1892 saw the last of these attempts. The final one was announced by Maquenne in "Comptes Rendus," CXV., p. 538-561, and in the same volume, p. 1031. Moissan announced the manufacture incidentally in describing his electrical furnace.

The reason for the pursuit of the carbides is obvious enough, men wanted ethine and they knew that cheap carbides stood for cheap ethine; and they imagined that because illuminating gas made from gas-coals contained a little, they could greatly improve it by adding more. But between the time the pursuit was started and that when the object was attained an entire change had come in the manufacture of illuminating gas.

The myth-makers are already busy with the story of the practical discovery of the manufacture of calcium carbide direct from quicklime and coke, and with that I have no concern; but undoubtedly it should be credited to Wilson, that while the making was a fortune-bringing accident, he had the good sense to see the value of that accident.

For some months my whole time and attention have been laid out upon the questions involved in this matter, and I am inclined to offer and am prepared to defend the conclusions which follow.

The most careful search demonstrates that, while the first publication of the results of scientific study of calcium carbide came from Henri Moissan ("Comptes Rendus;" Tome CXVIII., 5 March, 1894), long after the statement of the first mention by him as the result of the reduction of quicklime by carbon (coke). (Comptes Rendu, CXV., pp. 1031, Dec., 1892. both are later than the mention of this substance in a patent issued to Wilson in August, 1892. This forces the concession that Wilson made the discovery, and a reference to a paper by Maquenne (in Comptes Rendus, CXV., pp. 531) implies, by lack of mention, that Maquenne was practically ignorant of the matter.

There is a curious custom in these meetings of the Institute, to be seen in all the papers, that every member of the Institute at meetings ignores all work not that of members; therefore, it is quite possible that ethine made from calcium carbide may have been shown in Paris without any *legal record* before the dates given.

The discussion of the laws of relation among the electrical furnaces needs not to be entered upon here; but it is quite certain that the methods employed by the Morehead connection in manufacturing carbide are not those for which the Wilson patents were granted, and it seems to me rather of a burlesque on the learning of the Patent Office that the Wilson patent of June 18, 1895, should have been allowed after the thorough ventilation of the state of the art in all its details by Moissan in March 1894, as in the work of Moissan stress is laid on the crystalline condition of the carbide. The imprint of Moissan's communication reads: "Preparation au four electrique d'un carbure de calcium cristallise; proprietes de ce nouveau corps," date, March 5, 1894. The Wilson patent reads: "Claim. The production of crystallized carbide of calcium, a new product," date, June 18, 1895. The application for the patent was filed 361 days after the publication by Moissan of all that was needed by science or art for the reproduction of carbide indefinitely. It would be an amusing result if an attempt which, will surely be made, to overthrow this Wilson patent should make the manufacture free to all the world. It is now the opinion of practically all patent lawyers who have examined the question that the Wilson patents are waste paper.

The more this substance is studied, the more plainly it appears that there is room for much yet to be learned concerning the manufacture. Many are the scientific and practicable problems involved, as has been demonstrated in repeating the experiments of all interested from Wohler to Moissan. I beg leave to affirm that in addition to the CaC_2 union there are certainly others, and one of them seems to be more frequently produced by the Cowles process than by the Wilson. Incidentally it may be mentioned that a number of pounds of alleged carbide made by the Cowles process came into my hands which would yield neither ethine, methane nor hydrogen.

Still more singular were some of the vagaries of the samples made in North Carolina by the Morehead connection.

The Carbide of Calcium, CaC_2, of Wilson, Carbure de Calcium, Moissan; Acetylure de Calcium, Wohler and Maquenne, is a black pseudo-crystalline mass, of a maroon iridescence, when in the ideal form. It also forms in a black-gray, slag-like body, massive. A third form is black and seemingly porous. This form is inert. When the crystalline mass is thrown into water it yields ethine and ethine only; but the other never yields pure ethine, and, in fact, its product is never twice the same. Hydrogen comes off in amounts sometimes equal to the yield of ethine, and not infrequently methane. It is not my intention to enter into details now, but an experiment of Moissan ("Comptes Rendus" CXIX, July 2, 1894,) shows that the probable source of all the natural gas is the decomposition of aluminum carbide by water.

Substances Formed in the Amorphous Product.—Surrounding the crystallized carbide in the center of masses made by the Morehead process is always an amorphous mass. This mass is in many ways more interesting to study than the crystalline portion. It does not yield ethine so largely as the other, but it yields always hydrogen and often methane. It contains carbide in the form $Ca C_2$ and another carbon compound giving for the mass formula $Ca C + C$, but in whatever shape the molecule may be it is not decomposable by water. The formation of metallic calcium by direct reduction in presence of carbon must still be questioned; but the easiest way to explain the presence of hydrogen pure is: $Ca + 2H_2O = Ca2HO + H_2$. Among the curious things that have been found in these amorphous samples have been pale yellow pellets of an aluminum-calcium alloy.

The Method of Preparation.—In all the patents issued to Wilson is shown a furnace which is identical in all respects with the classic Siemen's type and in the articles in the "Gas Light Journal" the same appears. It is the Siemen's furnace with a part of his drawing left out and the balance disfigured; the electric governing apparatus is omitted. The implied purpose is to show the way in which carbide is manufactured. Now, in point of fact, there has not been one pound of carbide made in this way, and in the judgment of some lawyers, and good ones at that, the performances of the Morehead connection in using and exhibiting as a commercial process of making carbide, a method not protected, and trying to sell the same has brought into the conditions surrounding a problem that will make plenty of trouble for their "innocent purchaser" after the latter has made carbide a commercial success. In the method in actual use there is no crucible but an open hearth in which the material is piled and subjected to the current and as the center of the pile melts under the heat, pieces of boiler iron are set about so that the pile may be built higher.

The rapid cooling at the surface makes a column of fused amorphous carbide with a crystalline center in the midst of a heap of uninfluenced lime and coke, built up between two vertical electrodes, one of which is constantly retreating. To call this an operation protected by the Wilson patents exposes one to contradiction.

Be this as it may, I, personally, in laboratory experiments have made carbide as follows:

(a.) By the Wilson patent method.

(b.) By the Morehead practical unpatented method.

(c.) In a furnace using Cowles' methods of working.

(d.) By the Clarke patent methods.

(e.) By the unpatented method of Moissan.

And from these studies I have found that modifications of Moissan's multiple arc furnace will produce the carbide even more cheaply than the Morehead method.

The Determination of the Illuminating Power of Ethine.—It was not long after experiments in photometry were begun before I saw plainly that the difference in the colors of the light of ethine and common illuminating gas would throw doubt on any comparisons made in the ordinary way. This was the more evident because a spectroscopic examination showed so much difference in the relative amounts of the various colored rays. I therefore replaced the screen of the photometer by one made of paper with a grain. As a result the two fields appeared as illuminated spaces covered with innumerable dark spots and by moving the trial burner until an equality of darkness of spots in the bright fields was obtained, an accurate gage of the illumination was got notwithstanding a decided difference in the color of the two fields.

From a mean of eight series (covering more than 200 distinct observations) the fact came out that burned from a Bray 0000 lava tip, 1.4 cu. ft. of ethine per hour gives a light equivalent to that of 64 candles, although much whiter. This whiteness is, of course, hypo-chromatic.

The Ethine Value of a Pound of Carbide.—The unstable calcium carbide (CaC_2) in its purest and best crystalline shape will in theory yield about 5.5 cu. ft. of ethine per pound of carbide decomposed. In practice, however, this seems hard to obtain. It

may be because the carbide is impure, it may be because there are circumstances in which other carbides are formed; but 4.9 cu. ft. is the average of all my experiments. Accepting this as the average rather than the theoretical amount, it appears that the candle power value of a pound of carbide is $\frac{4.9}{1.4} \times 64 = 224$ candle power hours. There seems no escape from this conclusion, surprising as it appears.

The Utilization of Carbide and Ethine for Illumination.—Given the carbide, how shall we obtain the ethine, and having this how shall it be brought to the use of the householder? This involves the whole question of commercial development. The simplest answer to the question of getting the ethine from the carbide is to throw a piece of the material into water and collect the gas which is immediately set free; but as we cannot do this every few minutes, and as the yield of the gas is so large as to be difficult to manage, some mechanism for a continued supply must be introduced. Two plans of intermittent production are in common use among experimenters, one founded on the Kipp gas apparatus, the other on that of Fresenius. In the first the water is forced away from the carbide by the pressure of the gas; in the other the carbide is lifted out of the water as the gasholder rises. Both of these machines are wrong in principle, as they omit any notice of the fact that the vapor of water will decompose the carbide even below the freezing temperature, consequently the gas liberation is not discontinuous, but is only variable. Machines on this basis have been constructed and they are in use in private plants in several places: both the defects mentioned require the use of repeated charges of small amounts of carbide, or a disproportionately large holder. To meet this difficulty differential pressure valves have been added to holders and exaggerated pressures used in them, but the system has not worked well.

Another proposition is to use a very large holder such as the gas works employ and distribute the acetylene through the city street pipes. This method has the disadvantage that it allows an enormous waste. The tank leakage in gas works is serious enough now; but it would be increased about 18% with ethine, and that would be serious indeed.

If small tanks and large are both out of the question, there remains but one way to handle the product, compress it and sell it in bottles. This can be readily done, and is a way both simple and safe, it having already been proved that the bottled compressed gas is as easy to care for as an equal amount of water. By means of valves of the sort used on carbon dioxide bottles the pressure of the escaping gas can be easily regulated. At the present state of the art this seems to be the best way to handle ethine.

The Size of the Bottle.—It is asserted that in an average house the consumption of gas in Brooklyn is about 10 ft. per night per burner, and as the usual burner is a 5-ft. tip, it may be assumed that the average gas lamp is to be burned two hours per night. A bottle, then, which would hold 10,000 cu. ft. at the needed pressure would hold enough for three months, even if the consumption were as great as that of gas, and as the amount used would be only 25% that of ordinary gas, a holder of very moderate dimensions would do for a month's supply. Such cans as these could be handled as readily as those of the calcium light company. The present pipe systems could be used well enough, but the tips of the burners would need to be changed. The facts have been clouded by many words, but my own experience shows 2 ins. of water at the burner, and a Bray 0000 as the conditions of choice at present writing. Under these conditions 1.4 cu. ft. are burned per hour. It must be remembered that ethine has, after methane, the smallest specific gravity among hydrocarbon gases; it is therefore very hard to manage and requires a very small tip.

Three plans have been offered for the use of ethine as an illuminant, (a) to use it for enriching, (b) to burn it diluted with air, and (c) to burn it undiluted alone. There is something very funny in the proposition to enrich a gas principally made of cheap pseudo-acetylenes by adding a costly real one to it, but the absurdity of no scheme ever strikes a promotor if only he can find some one to believe in his ability to do the thing which he has undertaken. The logic of the proposition was something like this: In years long past and gone it was said that the then used gas would be improved by adding ethine; therefore, if we add ethine to the present gas we will improve it, taking no notice of the differences in the composition of the two gases. No more ill-considered project was ever devised. It is true that very small amounts of ethine added to the city gas, two parts per thousand for instance, will sometimes "improve" the candle power as read on a Bunsen photometer to some eyes, but to other eyes quite as well trained will "disimprove" it, and careful experiments with the spectroscope-photometer show improvement only at the lavender end, where no improvement is needed. My own experiments have been confined wholly to the hypo-chromatic spectrum produced, and at present only one conclusion is possible, and I think it will be amply verified, that any effort to improve the illumination spectrum of any hydro-carbon by adding ethine will be a failure.

Setting aside the use as an enricher, the use pure as an illuminant remains. Ethine can certainly be burned pure: yes, if any one wants the light. The question is one of desirability only, and if people care less for their eyes than they do for using ethine, by all means let them use the ethine: but they must take the consequences. Still if ethine is to be burned pure, it must be burned pure. The proposition to mix it with air and then burn it is utterly absurd, and it is hard to see how it obtained serious advocacy even for a moment. To mix air with any gas and burn it is to render the combustion more perfect, and while this will work with a mixture of many hydro-carbons of different breaking points it is destruction to the light-giving power of one whose fundamental condition of luminosity is that the combustion shall be incomplete. That a flame shall be luminous, it must smoke; vide the non-luminous condition of the Bunsen flame, in which the combustion is as perfect as it is possible to make it. A series of experiments conducted to ascertain the change in emission produced by adding air to ethine shows that the visible irradiation begins to decrease at the red end of the spectrum, in comparison with a unit yellow, when less than 1:500 of air is present. That the total irradiation is visibly decreased by the heating of the Bunsen photometer, when it reaches 2%, while equal parts of air and ethine give only 3%, and 2 parts air to 1 ethine only ¼ the irradiation of pure ethine. This is due not to a decrease in the light produced per unit area of the flame, but to a change in the flame area itself. The fact of the reduction is certain, but the explanations are so far unsatisfactory. It may be due to the fact that the gas burns to carbon monoxide inside the flame, thus heating the radiant carbon to a less degree than if it were burned at the surface, the carbon mon-oxide burning afterwards as a fringe above the luminous flame. That a fringe of burning carbon mon-oxide surrounds the flame at the top and on both sides is certain.

In the present state of the art the only way in which ethine can be used to advantage for lighting is to decompose the carbide to obtain the ethine, pass it over substances that will absorb any mixed in oxygen, then dry it, finally compress it into bottles and sell it just as carbon-dioxide is sold, "by the bottle." These screwed into fixtures connected with a system of house piping make a thoroughly efficient apparatus when provided with suitable tips, say Bray 0000.

The Value of Ethine in Terms of Other Sources of Illumination.—The defects in the reflection spectrum of ethine are those of all high-temperature carbon lights; but as it is the hottest of them all, it has these defects to the highest degree. The precautions which are needful in dealing with the other lights of its class applied to it will make it available and a dangerous rival for gasoline air gas. There are certain defects in the "greased air" illumination which are carefully minimized, but are inherent in the nature of the process employed, which can be avoided by using a compressed ethine. It will then be simply a question of choice. The persons who buy gas machines are not usually considerate of nickels, and the small marginal difference in cost will not affect their desire to have that which pleases.

That ethine will please because it shows the fashionable tints brilliantly is quite likely, but should the fashion change, and in place of lavender and "peacock tints" the warm reds and the deep blues become the fashion, a light showing them well would be in demand and ethine would be impossible commercially. Were ethine introduced, it might aid in keeping these tones in fashion, just as the incandescent light has induced the use of these same for decoration. The dead white room is now a necessity to obtain even an apology for illumination, and "dead white" is really blue.

In the larger field where cost must be considered, the case is not so plain. Expressed in candle power hours the value of a thousand feet of gas shapes itself as follows: 1,000 cu. ft. at 5 ft. per hour × 20 candle power = 4,000 c. p. hours at $1.25 per 1,000 cu. ft. This is 0.03125 cts. per c. p. hour, but the question of using ethine is not a question of cost per candle power hour based on the cost of carbide; there are a number of elements to be considered.

It is asserted that in an average Brooklyn house using 5 ft., i. e., 20 c. p., tips the consumption is 10 ft. per tip per night. From this it would seem that each burner is used say two hours. The introduction of ethine would not materially lessen the number of the tips, because in very few rooms is more than one burner a lighted one; but the conditions of the combustion of ethine require certain constants which may make it impossible to bring the light unit below 50 B. P. (Bunsen Photometer) candle power per burner. If the number of burners in a single house is 20, the consumption of gas per hour will be 100 ft., while the consumption of ethine would be 28 ft. or 0.28 of the gas consumption, and the candle power of emission will be 64 × 20, or 1,280, as against 400, or 3.2 times as much as gas.

Expressing these facts of B. P. candle power in a single equation shows that ethine is commercially only 15 times more radiant than gas, consequently to compete with gas it must not cost more than 15 times as much at the burner. This means that if 20-candle power gas sells for $1.25 per M., the ethine delivered at the burner must cost not more than $18 75 per M. One ton of "carbide" will yield, with needed care, 10,000 cu. ft. of ethine, worth, on this basis, $187.50. This is the promoter's comparison. On the other hand, the unit burned of ethine in candle power is needfully larger: in place of 20 B. P. candle power units 64 B. P. candle power seem to be, and at present are, the smallest practicable burners. This brings the margin down materially. In place of ethine selling at $18.75, the prohibitive price comes at $4.50, and the ton of carbide is worth only $45. In competing with gas in city consumption the carbide has a maximum price, which is also dangerously near the minimum.

Gas (common illuminating) can evidently be much cheapened; suppose it came down to $1, would the carbide be a competitor then?

While this matter must remain "sub judice," there is no doubt that carbide must be reckoned with as a commercial rival by all the parties interested in producing illuminants: in cleanliness and safety it finds no rivals among the Standard's products, and the question becomes simply one of price.

It is perfectly well-known to all who have examined the question that the Willson patents are simply waste paper so far as protecting the monopoly of the manufacture and use of carbide are concerned. The ridiculous posturing of this interest has undoubtedly injured the future of carbide for many a day; still, as the manufacture is free to all the world, it is to be expected that we will hear more falling of walls and less blowing of trumpets in the near future.

There are but two limitations in the carbide production, the productiveness of a HP., and the price of it. The maximum productiveness of the HP., beyond which it cannot go, is 1.374 lbs. of carbide per hour, say 33 lbs. per HP. day of 24 hours. How near this can be approached, I do not know. Logs of many days run, at Spray, N. C., show that 15 lbs. per HP. at the dynamo per 24 hours have been made, say an efficiency of 50%. This from my standpoint seems to prove a very great deal. The cost of a HP. day by water is very small, and there is no need of making a bugaboo of it.

The choice of Niagara as the site of a manufacture so purely experimental and so unsatisfactory in many ways, raises doubts as to the judgment of the managers of the business. Still they probably made the choice with their eyes open, and it is safe to conclude that if they had not had some good reason they would not have chosen such a place, when so many water powers enough and to spare

for their needs for many years could be obtained for so much less money.

At Mr. Morehead's figures, 1 HP. at the dynamo is worth 33¾ cts. per 24-hour day, and certainly 1 dynamo HP. can be provided at 1.4c. per HP. hour, if pains be taken in the selection of sites and machines.

There are two directions in which improvements can be made; the burners can be improved so that in place of a consumption of 1.4 cu. ft., and a 64 c. p. (B. P.) unit, a consumption limited to 0.45 cu. ft. and 20 c. p. unit shall be reached. This would instantly bring the value of a ton of carbide up to the promoters' figures and make the Morehead HP. value 4.48 cts. per HP. hour. At the same time an increase in the efficiency of the furnaces to say 80%, which is, I am told, the efficiency of the Herault process, would raise the product to 27 lbs. per HP. day at the dynamo.

Either one of these improvements would put ethine in the market as a rival for coal gas, electric lighting and even the common kerosene oil lamp.

More than a dozen expert men are working on these problems, and any day the much wanted burner may come to hand and with it a revolution in the financial status of those who will doubtless appreciate the advantage of being first in a commercial field.

Once given a burner which will burn ethine properly and carbide industries will spring up all over the country, without any bubble blowing or professional promotion. There will not only be a carbide industry, but a great many carbide industries.

SOME FACTS ABOUT ACETYLENE GAS.*

By John C. McMynn, M. E.

Acetylene gas has been known for many years as a laboratory product too expensive for anything but experimental use. A possible method of producing this gas on a commercial basis was developed in the electric furnaces of the Willson Aluminum Co., at Spray, N. C., by Mr. T. L. Willson, while experimenting with the production of aluminum and the smelting of other very refractory substances, such as lime, silica, calcium, etc., under the direction of Major J. T. Morehead, the president of the company, and a geologist of nearly national reputation. Experiments were being conducted with a view of combining the metal calcium with other metals, and in the course of such experiments lime and coke were fused together and the resulting product thrown into water, when it produced a violent bubbling by giving off a gas which, when lighted, gave an intensely brilliant flame. A long series of experiments followed, made by Dr. De Claienot and Major Morehead, to determine the correct proportions of lime and coke, together with the analysis of all mixtures and resulting products.

In a recent visit to Spray, N. C., I found a very primative electric furnace, the current for which is furnished by two 120 K. W. alternators. The voltage is transformed down to about 100; the carbons are 12x8 ins. and 36 ins. long, and with between 1,300 and 1,400 amperes the brilliancy and intense heat produced can hardly be imagined unless seen. Finely powdered coke and crushed lime are thrown between the carbons and fused in the intense heat which results in the production of calcium carbide. This is a black crystalline substance, very hard and insensible to heat, but when placed in water produces a carbon vapor through the chemical combination of two parts of carbon with two parts of hydrogen, and which possesses the highest illuminating power of any known gas. The calcium combines with the oxygen of the water, thus making a double decomposition.

A company was formed to develop its production and to sell rights for its manufacture. The new product has been the target for all the usual criticisms, and such papers as "The New York Tribune" and "The Engineering and Mining Journal," in recent issues, have asserted that there was never a ton produced in this country, and if there were it would have cost over $100 per ton. These statements can only be excused through a biased determination to oppose any new process, or a disinclination to investigate both sides of a question. That the new gas will be a rival to electricity cannot be denied; and, as owners and managers of electric lighting plants, it behooves the members of this association to investigate the subject for themselves and to decide as to its value as an opponent to not only the incandescent, but the arc light, and not to take the advice of such electrical papers as are too cowardly to state the truth or too lazy to investigate. While at Spray every facility was given me to fully examine the plant and to make measurements of all factors entering into its manufacture. I regret that at this time I cannot make my report public, but I can state most emphatically that while I was there two tons of calcium carbide were produced in two days, and at a cost of about $25 per ton. Samples of this carbide produced an average of 5.13 cu. ft. of acetylene gas per pound of carbide. The methods used at Spray can be improved upon by any one building a new plant, and many of the losses can be eliminated.

In regard to its use as an illuminant, acetylene gas, when burned in a tip using 1 cu. ft. per hour, will produce about 50 c. p., but the flame is a solid flame, having no blue portion near the burner, and it seems to diffuse much more than this amount of light, because of the fact that its spectrum is nearly identical with that of the sun. A ½ cu. ft. tip will give a flame that is ample for all purposes of house lighting, and these tips will be most generally used. Admitting that these tips will replace the common 4 or 5 cu. ft. tips, we would have ½ cu. ft. giving more light than 4 cu. ft. of common gas; or 1,000 cu. ft. of acetylene giving more light than 8,000 cu. ft. of ordinary gas. The average price for gas in six plants in Southern Wisconsin is $1.76 per 1,000 cu. ft., hence the corresponding price for acetylene gas would be $4.08 per 1,000 cu. ft. That is, acetylene gas could give the same amount of light per 1,000 cu. ft. for this price. But the fact is that this gas can be produced at any suitable electric plant in Southern Wisconsin for a maximum figure of $5 per 1,000 cubic feet.

The gas can be used in several ways, as follows: (1) Distribution through mains is not the most advisable methods, since leakage would be a large factor and the original investment large. (2) The carbide can be distributed to residences and a small automatic generator placed in the basement, in which a week's supply could be stored. A house having 20 burners would probably use 10 burners for about four hours per day, and with ½ cu. ft. tips would consume 140 cu. ft. of gas per week, or about 28 lbs. of calcium carbide, at a cost of 3 cts. per lb. would give a gas bill of $3.36 per month, and the house would be much more brilliantly lighted than it could be in any other way, except by a larger number of incandescent lights. (3) A valuable property of the gas is that it will liquefy itself if the resulting gas is confined when water is added. This liquid gas is to be distributed in cylinders similar to carbonic acid gas cylinders (as used for soda water fountains), and when admitted to the house-mains through pressure reducing valves it assumes all its gaseous qualities.

To sum up the situation from an electrical standpoint: This is a new gas, having an illuminating power of much greater than common gas. No investment for street mains is necessary, hence the gas companies must use it either as an enricher or as an adjunct to their present system to supply isolated buildings and residences which can be reached neither by their present mains nor by electric lights. If they obtain the rights for this gas, they will have a weapon which will be as much stronger than the Welsbach burners, as the acetylene flame is stronger than the Welsbach light. To produce this gas or calcium carbide, the gas companies must put in electric plants, which, when not in use making carbide, can be placed in competition in electric lighting.

There are places and many of them where nothing will ever supersede the use of electric lights, but when you consider that only 5 % of the residents of Southern Wisconsin are reached by gas and only 30 % are reached in Milwaukee, and that even less can be supplied with electric lights, there is a field opened which is wonderful in the possibilities for successful investments and large business.

Most of your lighting plants are idle during at least half the time, and could thus be made producing plants for the whole time, and you could reach a territory which cannot be reached by either the gas companies or yourselves without large outlays for extensions; and, in most cases, not reached at all.

Of the following facts I am certain:

1. The gas is intensely brilliant.

2. It has a decidedly disagreeable odor if it escapes without being burned, and when burned emits no odor or smoke.

3. The gas can be distributed for much less cost (considering the interest on the investment) in cities, and also to every resident of the State, whether in the city or country.

4. The same amount of light can be produced for much less cost than by ordinary gas or electricity, for ½ cu. ft. of acetylene gas burned per hour gives more illumination than a 16 c. p. incandescent light, or 5 cu. ft. of ordinary gas. Allowing a maximum cost of $50 per ton for carbide, delivered either as a liquid or as carbide.

16 c. p., with acetylene (½ cu. ft. per hour), costs	0.160 ct.
16 c. p. incandescent costs, practically	0.600 ct.
16 c. p. ordinary gas at $1.76 per 1,000 cu. ft., with 4 ft. tip, costs	0.704 ct.

The above figures are based on the present method of manufacture and maximum cost, and no allowances are made for the improvements which must necessarily follow experimentation by practical men.

*A paper read before the Northwestern Electrical Association.

The substitution of masonry for the timber lining of the great Stampede tunnel through the Cascade Mts. in Washington has just been completed by the Northern Pacific Ry. Co. The work has been under way since 1888, having been begun directly after the tunnel was put in use. Its total cost has been about $500,000. The lining consists of concrete sidewalls and a brick arch, and extends throughout the whole length of the tunnel, 9,844 ft. Similar work has just been completed in the Mullan tunnel, extending 3,850 ft. through the main range of the Rocky Mts., and a tunnel 200 ft. in length, near the Stampede, has also been re-lined. Further work of the same kind will shortly be instituted at the Bozeman tunnel, through the Belt range between Helena and Livingstone, Mont. All this work has been done by the Northern Pacific Ry. Co.'s forces, under the direction of its engineering department, resulting in great economy. The first year at the Stampede tunnel the work of lining cost $125 per lin. ft. At the end of the work improved methods and experience had reduced the cost to $34 per lin. ft. The removal of the old timber lining presented a difficult problem, much of it having become rotten, and some of it being overlaid with loose rock. It was effected by means of dynamite, and specially constructed heavy cars having side platforms. A small charge of dynamite was inserted in a hole bored in one of the overhead timbers of the section to be removed, and on being fired the timbering and all loose material above it fell on to the top of the cars. By means of this method work could be done with any sort of material, except quicksand, above the timbering. Not a life was lost in removing the timbering. The above information was kindly given to a member of the editorial staff of this journal by Mr. E. H. McHenry, Chief Engineer of the Northern Pacific Railway Co., at his office in St. Paul. The Stampede Tunnel was described at length in our issues of Oct. 3, 10 and 17, 1891, and the new lining of the Mullan tunnel, as then in progress, in our issue of Oct. 25, 1894.

The question of operating trolley cars on the new East River bridge is discussed in a report to the commission made by its Chief Engineer, Mr. L. L. Buck. This report says that if trolley cars are to be used on the bridge under present conditions, they must be run singly, or with motor cars and three or four trailers. Any such arrangement would be inadequate during the crowded hours on one track. Mr. Buck says that at least two tracks in the direction of travel would be needed to handle the traffic. As elevated tracks are to be provided for also, he suggests, as the best arrangement, placing the two elevated road tracks in the center, with two trolley tracks on each side of them, or six tracks in all. With this arrangement proper cross-overs could be made for each set of tracks. Under present conditions of traffic the live load over the whole bridge, including roadways and footwalks, would not exceed 10,000 lbs. per running foot of the bridge; but he would prefer to provide for further contingencies by calling this 12,000 lbs. Mr. Buck does not think that the six-track project will cost more than his former estimate for a four-track bridge, as he assumed a higher load per lineal foot in the original estimate. But if the width of the bridge is limited to 113 feet, the footwalks would have to be placed over the carriage-ways. Except for right-of-way it would cost no more to put them outside the carriage ways.

The proposed deepening of the Erie Canal through Rochester, N. Y., affects 24 street bridges in that city, and Mr. McClintock, Cy. Engr., makes some important suggestions in a late letter to the City Council on this head. If the bridges must be raised 3 or 4 ft., as now assumed, the change in street grade would injure the streets and damage a large amount of property. Rochester is at the lower end of a canal level 62½ miles long, and when built this level was planned to have a fall of at least 5 ft. 2 ins. in its length, in order to insure a sufficient flow from Lake Erie. The survey of 1840 showed that instead of having a fall of about 1 in. per mile, as intended, the fall was only ½-in. per mile for the 40 miles from Lockport to Brockport, and was level to Rochester. Since that date the eastern end has been deepened and the banks on the western end raised so that the actual slope is about 38 ins. in the 62½ miles. Mr. McClintock says that this slope is not sufficient to induce the flow intended, and he suggests that the eastern end should be depressed 3 ft. on the bottom and 1 ft. at the surface. This, he claims, would insure a proper flow from Lake Erie, reduce the trouble in passing through Rochester and do away with the necessity for depending upon the Genesee water for canal use.

The long-abandoned mine of graphitic anthracite coal at Portsmouth, R. I., it is stated in a Providence paper, is to be reopened by a new concern called the New England Anthracite Coal Co., composed of New York and Boston parties. It has long been believed that the coal cannot be successfully burned, but the proposition now is to grind it, add enough pitch or oil to make it free-burning, and deliver it in egg-shaped briquettes, made by automatic machinery.